FINAL REPORT

WYOMING SOIL CARBON DATABASE AND MAPS

Submitted to the

CARBON SEQUESTRATION ADVISORY COMMITTEE

and

Wyoming Department of Agriculture, Cheyenne, WY

July 24, 2002

by

Dr. George F. Vance
Department of Renewable Resources
University of Wyoming
Laramie, WY 82071-3354

INTRODUCTION

On December 18, 2001, the Wyoming Department of Agriculture and the University of Wyoming entered into a Memorandum of Understanding (MOU) for the purpose of developing a soil carbon database for all Wyoming counties in the state. The responsibilities of the MOU were as follows:

1) To develop a county and state database of soil mapping units, soil series and subgroups utilizing Wyoming soil information developed by Munn and Arneson (1998) that is accessible through WyGISC.

2) To access NRCS's soil characteristics database (National Soil Survey Center - Soil Survey Laboratory 2001) to determine which soils series and subgroups can be used to determine soil carbon contents.

3) To prepare GIS data layers of county maps that contain carbon levels for the upper 15 cm and upper 1 m depths.

4) To integrate county maps into a homogeneous state GIS data layer that depicts carbon contents in the upper 15 cm and upper 1 m depths.

5) To provide GIS-derived maps for Wyoming counties and the state showing areas of carbon contents within the upper 15 cm and upper 1 m depths.

DEVELOPMENT OF SOIL CARBON ESTIMATES

The statewide representative soil series in the soil mapping units (SMUs) within each county were used to develop the weighted soil C concentration relationships among the SMUs. Appendix 1 includes the database that was developed for the individual SMUs in each of Wyoming's 23 counties.

After identifying the various soil series, soil characteristics were obtained from the NRCS's Soil Database (URL: **http://vmhost.cdp.state.ne.us:96/SERIC.HTML).** From this data, organic carbon values in the upper 15 cm and the upper 1 m of the soil were computed for each series with data. In some cases, estimates were made for the bulk density based on data from similar soil series. For soil series that had no data, data from soil series that were in the same or closely related subgroups with similar temperature regimes and textures were used. In addition, we utilized complementary soil series within surrounding states to obtain soil C data. For cases were numerous data existed, the information was averaged for soil series C contents. A general evaluation of the average C content in the different Wyoming Soil Orders are shown in Table 1.

Table 1. Average C contents in the 15 cm and 1 m depths for different soil orders in Wyoming.

Soil Order	Carbon Contents (kg/m^2)	
	Upper 15 cm	Upper 1 m
Alfisols	2.5	8.8
Entisols	2.3	8.9
Aridisols	2.6	8.9
Vertisols	2.4	10.7
Mollisols	3.7	11.1
Inceptisols	4.8	15.9

To compute SMU C contents, a weighted percentage of the C in each series was used based on the dominance of the soil series in the SMU. Table 2 provides the procedure for determining how soil series information was weighted for each SMU.

Table 2. Weighted percentages used to determine the soil C contribution of each soil series in an SMU. See example below.

Number of Series in a SMU =	**1**	**2**	**3**	**4**	**5**
Percentage used to calculate the SMU Carbon	**100**	**65**	**50**	**40**	**35**
		35	**30**	**30**	**25**
			20	**20**	**20**
				10	**15**
					5

For example, if a SMU consisted of three (3) soil series, the soil C content for the most dominant series was weighted at 50%, the next most common series was weighted at 30% and the least common series was weighted at 20%.

DEVELOPMENT OF SOIL CARBON CONCENTRATION MAPS

Appendix 2 contains the statewide C concentration maps that were developed for the upper 15 cm and upper 1 m depths. Appendix 3 contains the Wyoming county C concentration maps that were developed for the upper 15 cm and upper 1 m depths. The Maps were constructed used the natural breaks approach for separating the SMU carbon data into 5 classifications. This was completed in order to provide illustrative maps.

I. Statewide Carbon Concentration Maps

The statewide maps of C concentration in the upper 15 cm and upper 1 m soil depths are based on the 1:500,000-Scale Digital Soils Map of Wyoming. This layer contains 45 separate soils descriptions across 10 Wyoming soil zones. The layer was compiled based on the five-factor soil forming model using digital surficial geology, bedrock geology, and elevation. These coordinate system used to represent these data is UTM, Zone 12, North American Datum of 1983, with units of meters. This dataset and metadata for this layer can be found at:

<URL:http://www.sdvc.uwyo.edu/24k/soil500.html>

This original dataset on which the carbon maps is based is documented in the report: Munn, L.C. and C.S. Arneson, 1998. Soils of Wyoming: A Digital Statewide Map at 1:500,000-Scale. Agricultural Experiment Station Report B-1069. University of Wyoming, College of Agriculture, Laramie, Wyoming.

The dataset covers the following area:

West_Bounding_Coordinate: -111.26477012
East_Bounding_Coordinate: -103.83670034
North_Bounding_Coordinate: 44.99903411
South_Bounding_Coordinate: 40.94837176

II. County Carbon Concentration Maps

The county C concentration maps are based on the 1:100,000-Scale Digital Soils Map representing soils of Wyoming at 1:100,000-scale. These layers contains 349 separate SMUs that describe soils across all 23 Wyoming counties. The layers were compiled based on the five-factor soil forming model using digital surficial geology, bedrock geology, and elevation.

This dataset is more fully documented in 23 Agricultural Experiment Station publications. These publications use the designation Agricultural Experiment Station Bulletin B-1071 followed by a two letter abbreviation for each county.

This dataset and metadata may be found at the following link:

<URL:http://www.sdvc.uwyo.edu/100k/soil100.html>

The dataset covers the following area:

West_Bounding_Coordinate: -111.26477012
East_Bounding_Coordinate: -103.83670034
North_Bounding_Coordinate: 44.99903411
South_Bounding_Coordinate: 40.94837176

For all county maps, horizontal positions are specified in geographic coordinates, i.e., latitude and longitude. Latitudes are given to the nearest 0.001. Longitudes are given to the nearest 0.001. Latitude and longitude values are specified in Decimal Degrees. The horizontal datum used is North American Datum of 1983. The ellipsoid used is GRS1980. The semi-major axis of the ellipsoid used is 6378206.4. The flattening of the ellipsoid used is 1/294.98.

III. All Maps

Other data layers displayed in both statewide and county maps include Lakes, major Rivers, Cities, and Major Roads. These layers are described in more detail below.

Lakes and major Rivers

These data are a subset of the 1:100,000-scale Hydrography for Wyoming (enhanced DLGs) (Analysis, Wyoming Gap , 1996, 1:100,000-scale Hydrography for Wyoming (enhanced DLGs): Spatial Data and Visualization Center, Laramie, Wyoming) including only major streams (order 4 to 7) and major lakes and reservoirs.

This dataset and metadata may be found at the following link:

<URL:http://www.sdvc.uwyo.edu/24k/hydro100.html>

Roads

These data are a subset of the Wyoming Roads – TIGER data (US Census TIGER files, 199711, Wyoming Roads - TIGER: Spatial Data and Visualization Center, Laramie, WY.) including only federal and state highways. These data are at the 1:100,000 scale.

This dataset and metadata may be found at the following link:

<URL:http://www.sdvc.uwyo.edu/clearinghouse/road/quad.html>

Cities

This Wyoming Cities coverage (Spatial Data and Visualization Center, 19961211, Cities, Towns, Census Designated Places of Wyoming: Wyoming Water Resources Center GIS Lab, Laramie, Wyoming) contains data for 109 Wyoming towns, cities, and Census Designated Areas. All data used in the generation of this coverage was based on US Census information downloaded in 1996, though

the actual source information may not be current to 1996. The coverage was created from U.S. Census Bureau Tiger Data.

This dataset and metadata may be found at the following link:

<URL:http://www.sdvc.uwyo.edu/clearinghouse/human.html>

USEFULNESS OF SOIL CARBON DATABASE AND MAPS

Data layers and maps can be used for baseline examination of estimated soil carbon contents throughout Wyoming.

The generalized soil carbon content maps can be used for broad-scale planning and general assessment.

Alternative land, forestry and cropping management practices can be evaluated when carbon data base is combined with data for climate, vegetation, and land use.

REFERENCES

Munn, L.C. and C.S. Arneson. 1998. Soils of Wyoming: A Digital Statewide Map at 1:500,000-Scale. Agricultural Experiment Station Report B-1069. University of Wyoming, College of Agriculture, Laramie, Wyoming.

Munn, L.C. and C.S. Arneson. 1999. 1:100,000-Scale Digital Soils Map for Wyoming Counties. Agricultural Experiment Station Bulletin B-1071-xx (total of 23 bulletins, one for each county). University of Wyoming Agricultural Experiment Station, Laramie, Wyoming.

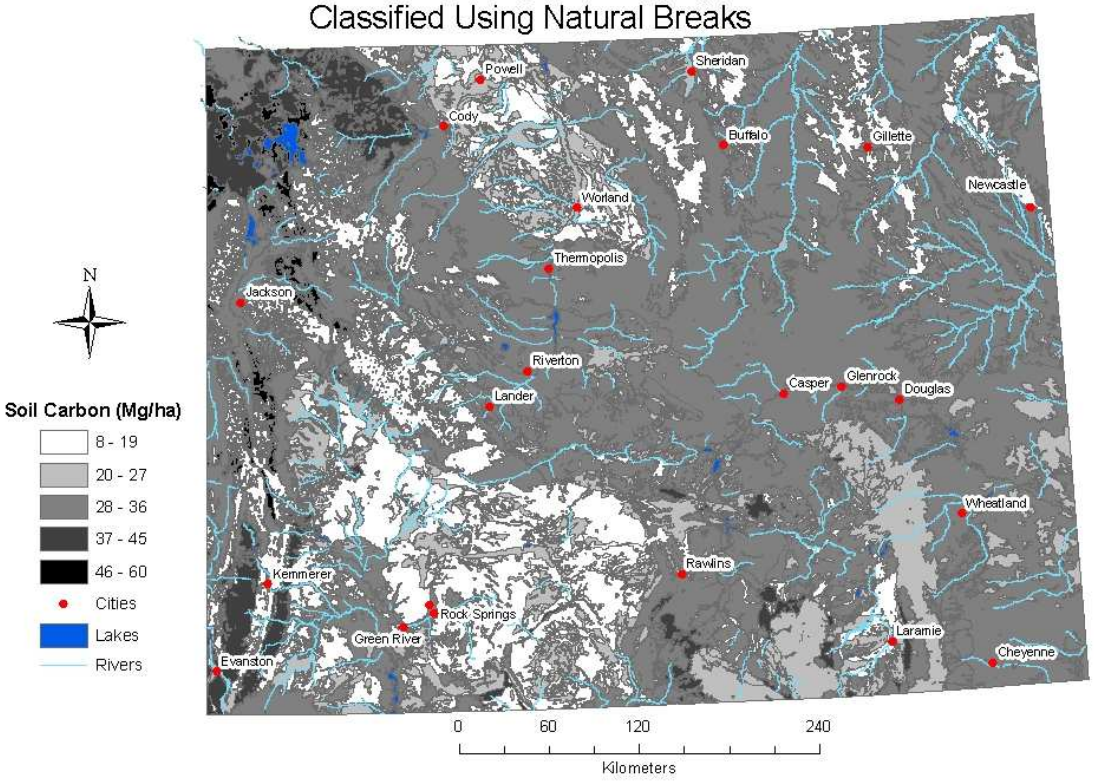
APPENDIX 1

Soil Database for the Calculation of Carbon in the upper 15 cm and upper 1 m depths of Wyoming SMUs

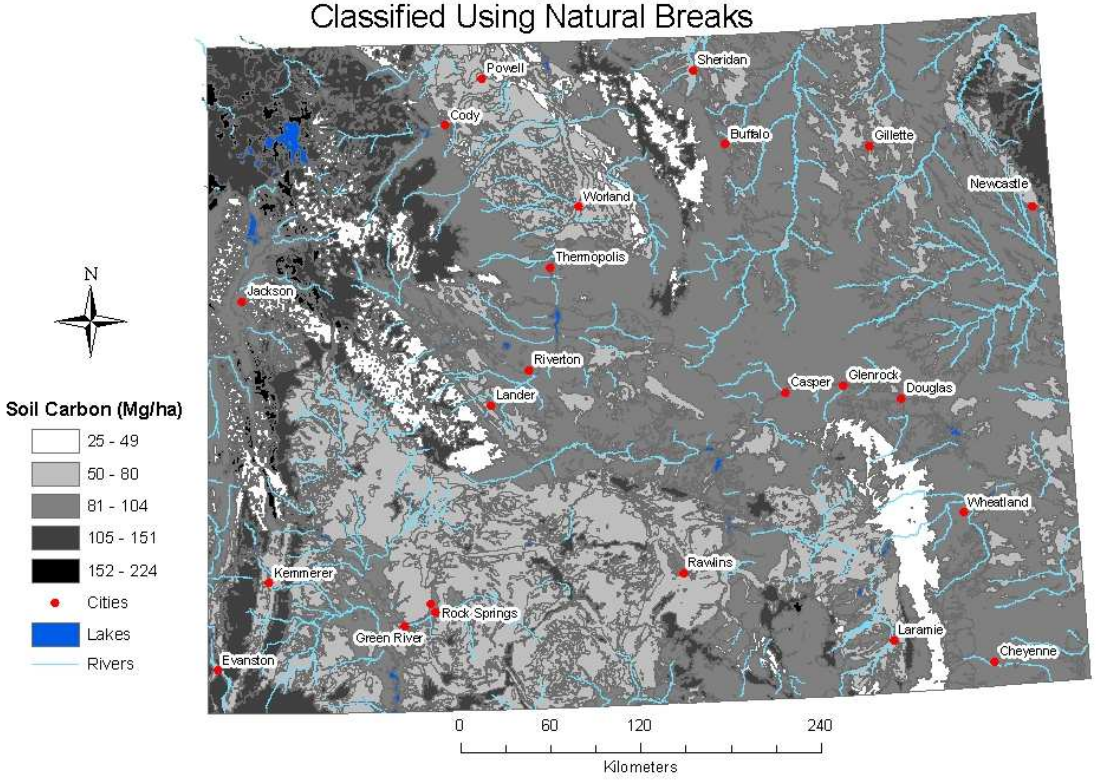
APPENDIX 2

Statewide Soil Carbon Contents in the upper 15 cm and upper 1 m depths using Natural Breaks Classification

State of Wyoming
Soil Carbon (15 cm depth)
Classified Using Natural Breaks



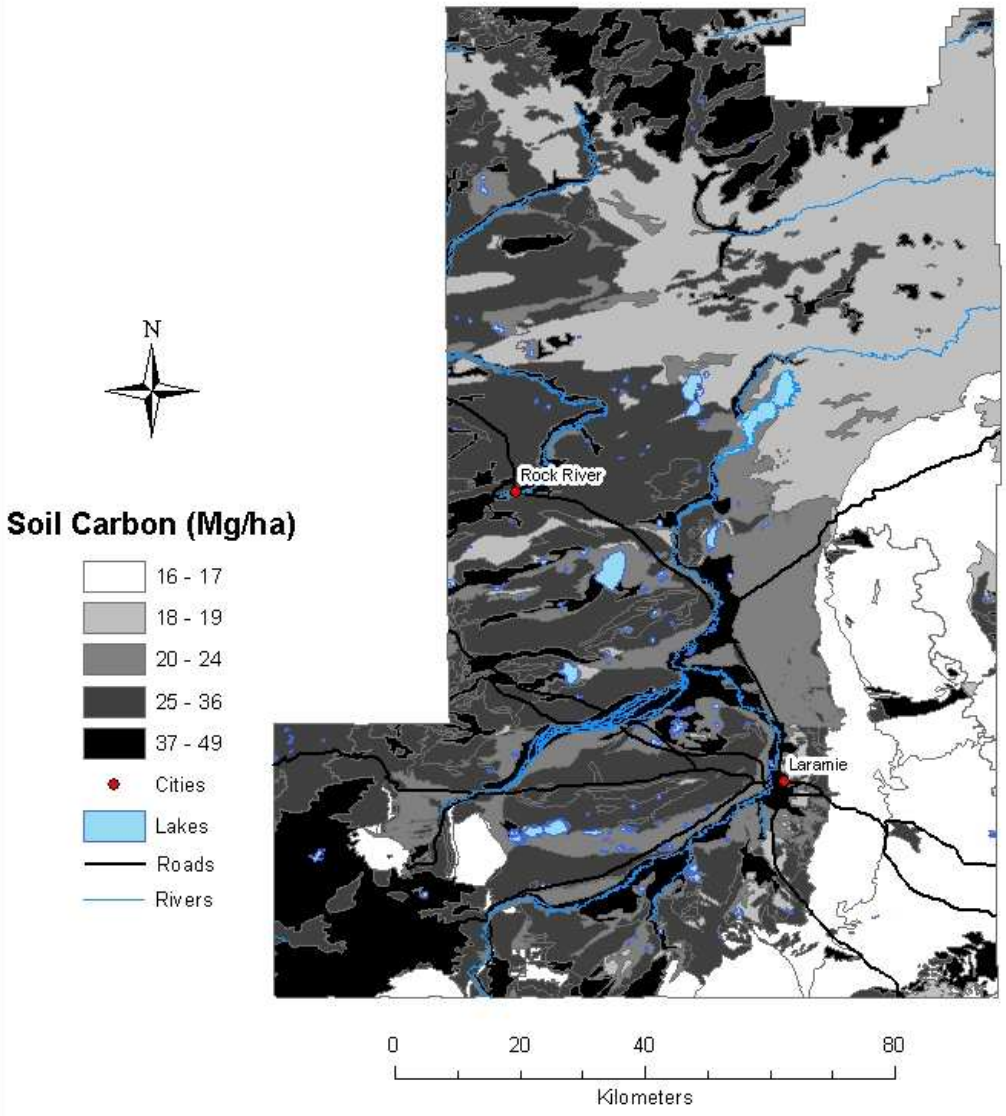
State of Wyoming
Soil Carbon (1 M depth)
Classified Using Natural Breaks



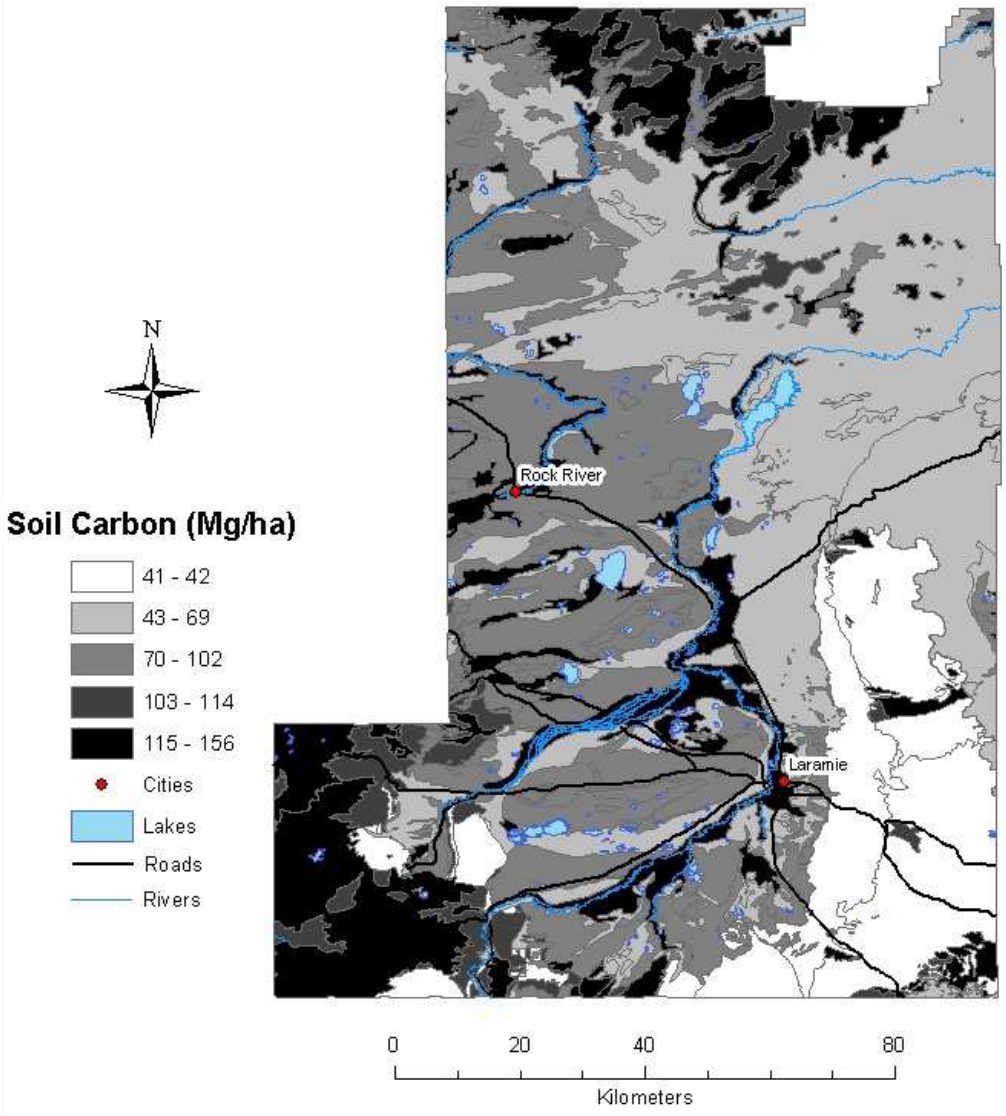
APPENDIX 3

Wyoming County Soil Carbon Contents in the upper 15 cm and upper 1 m depths using Natural Breaks Classification

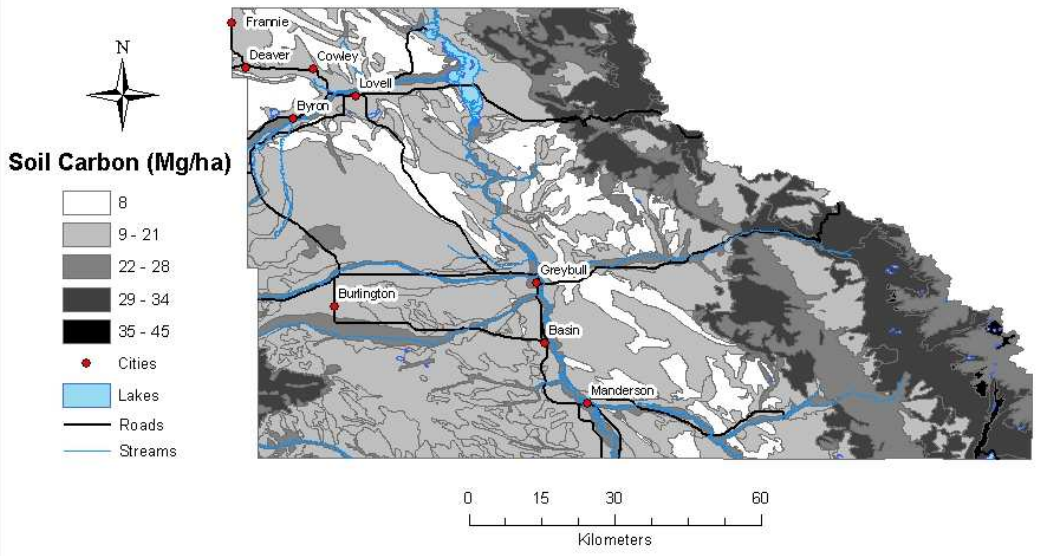
Albany County
Soil Carbon (15 cm depth)
Classified by Natural Breaks



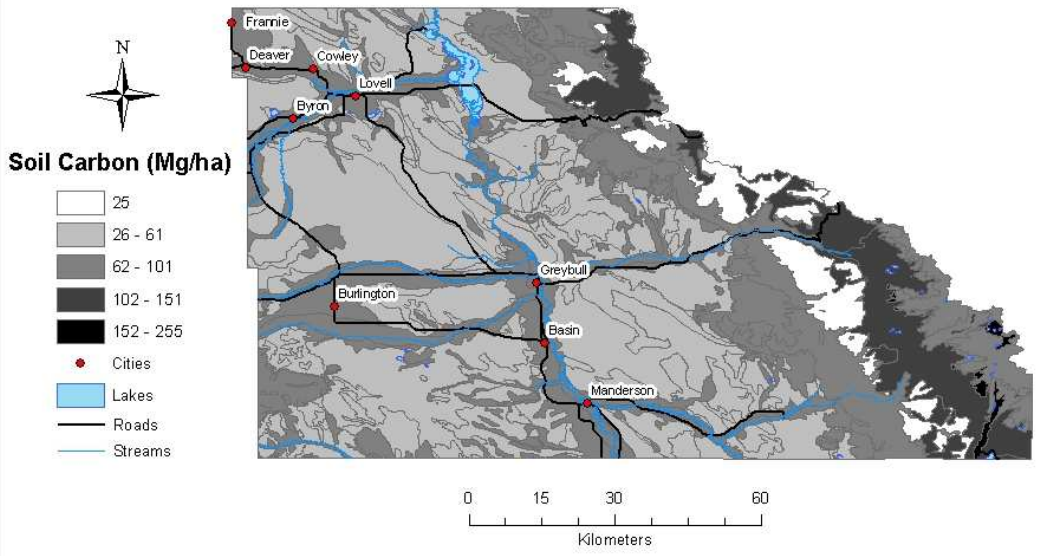
Albany County
Soil Carbon (1 M depth)
Classified by Natural Breaks



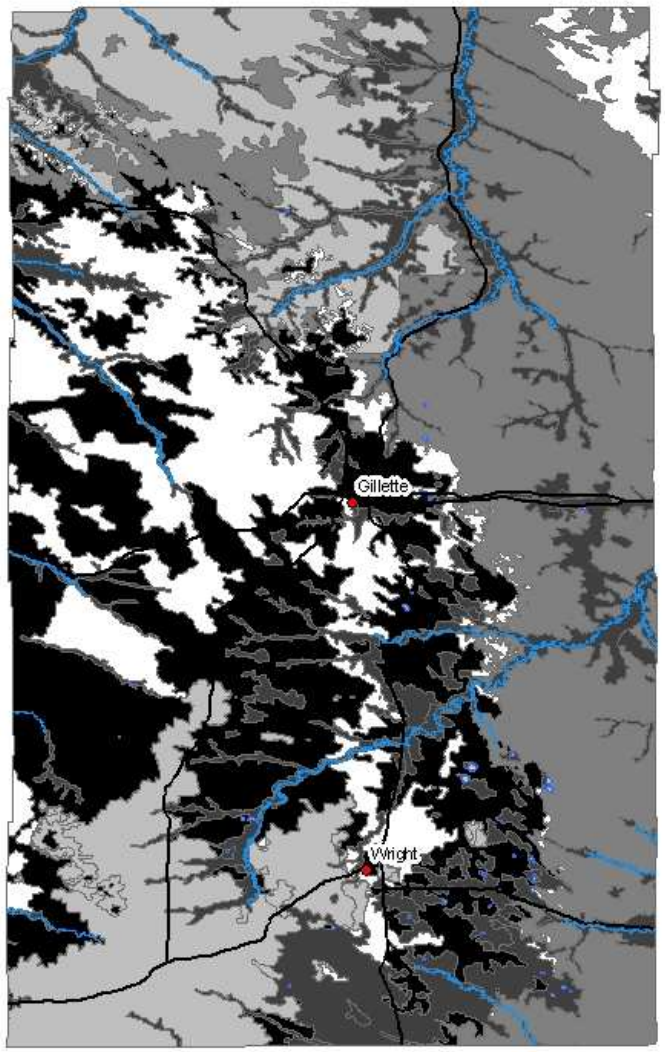
Big Horn County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



Big Horn County
Soil Carbon (1 M depth)
Classified using Natural Breaks



Campbell County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



N

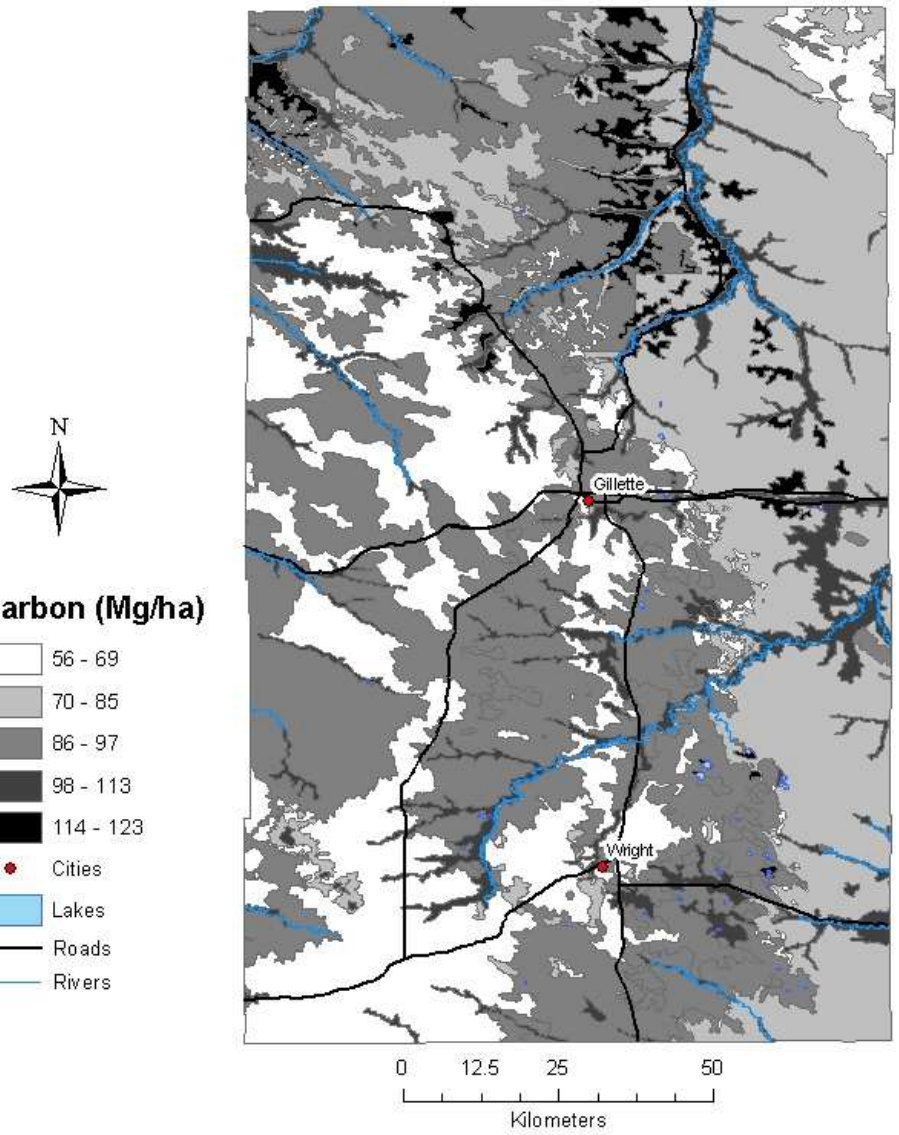
Soil Carbon (Mg/ha)

- 15 - 16
- 17 - 21
- 22 - 25
- 26 - 27
- 28 - 35
- Cities
- Lakes
- Roads
- Rivers

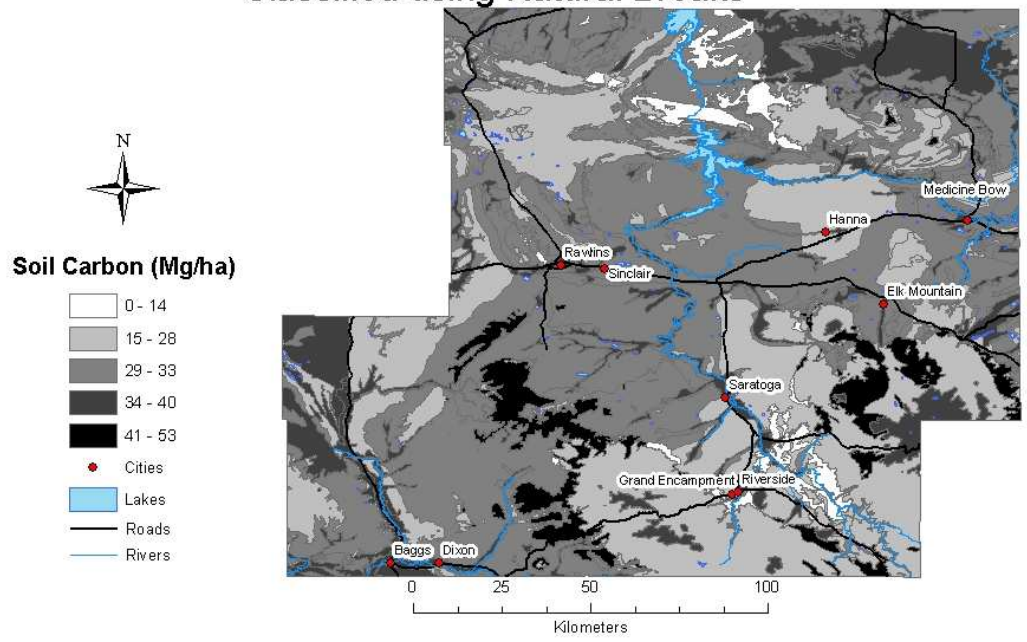
0 12.5 25 50

Kilometers

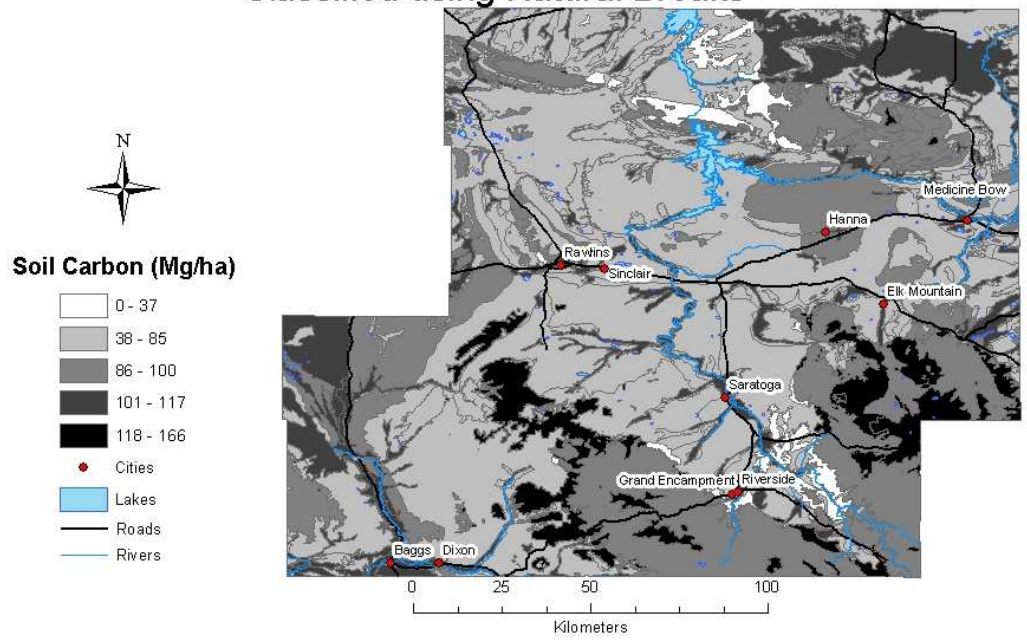
Campbell County
Soil Carbon (1 M depth)
Classified using Natural Breaks



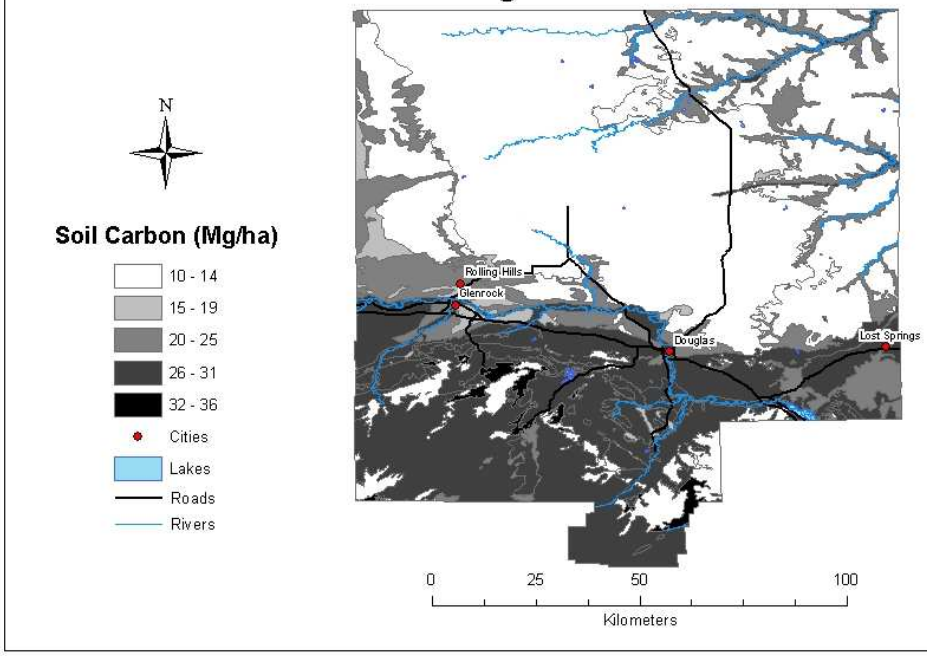
Carbon County
Soil Carbon (15 cm depth)
Classified using Natural Breaks

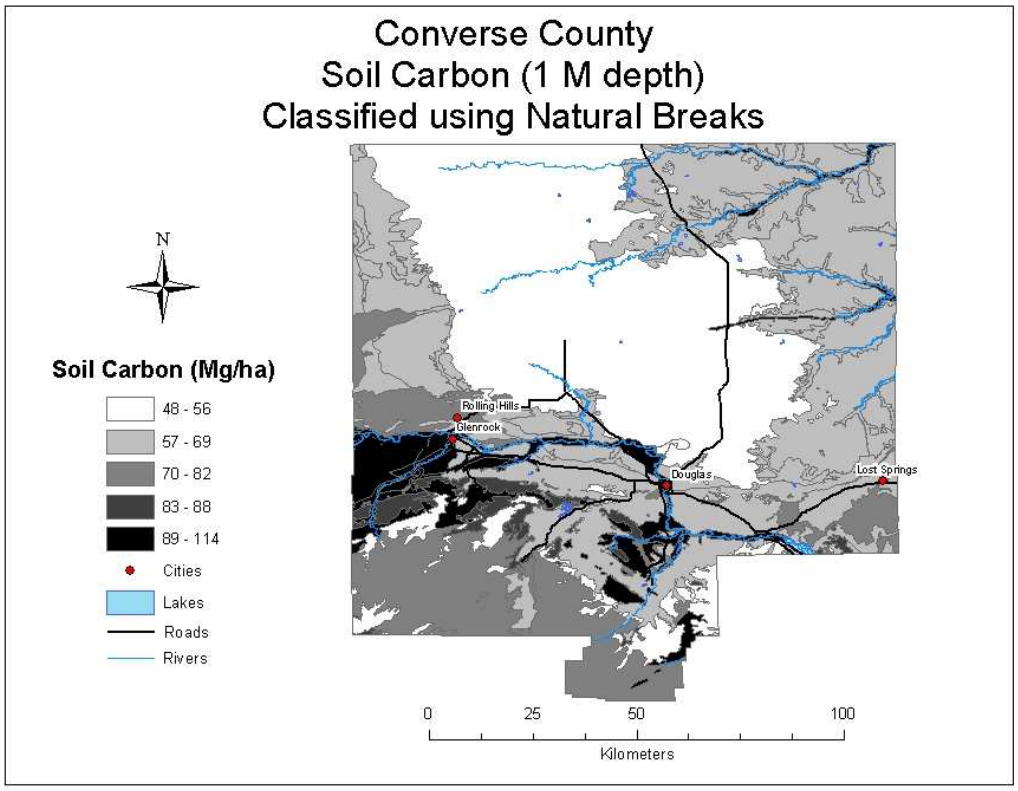


Carbon County
Soil Carbon (1 M depth)
Classified using Natural Breaks

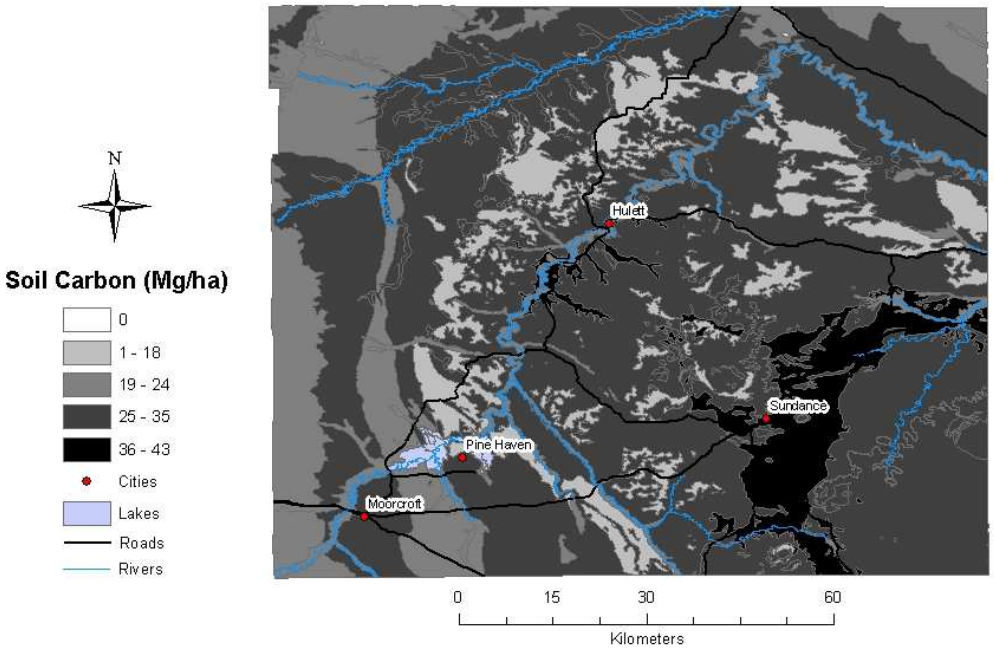


Converse County
Soil Carbon (15 cm depth)
Classified using Natural Breaks

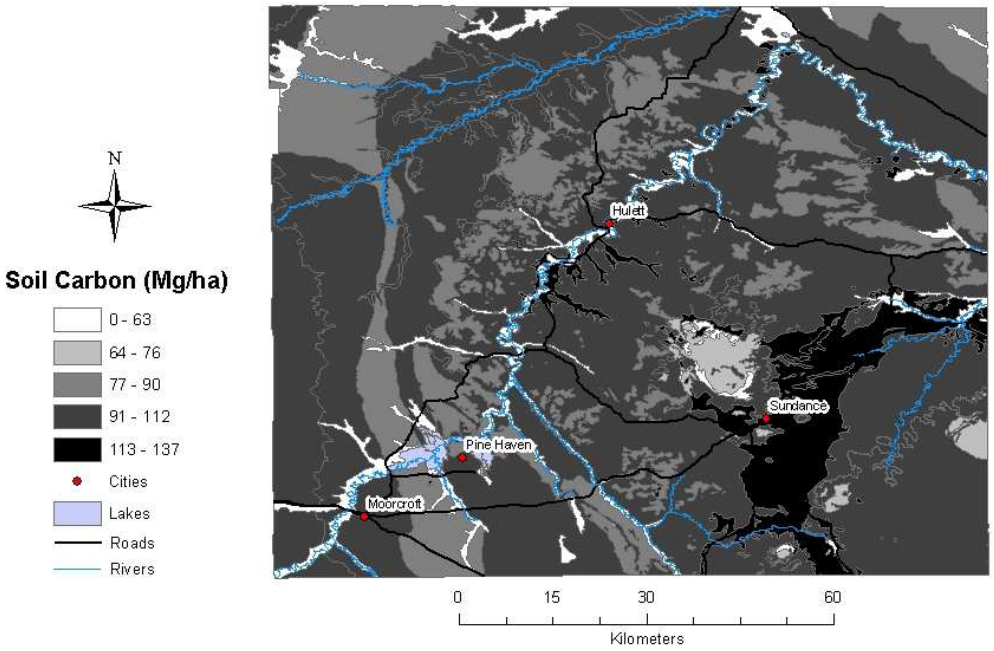


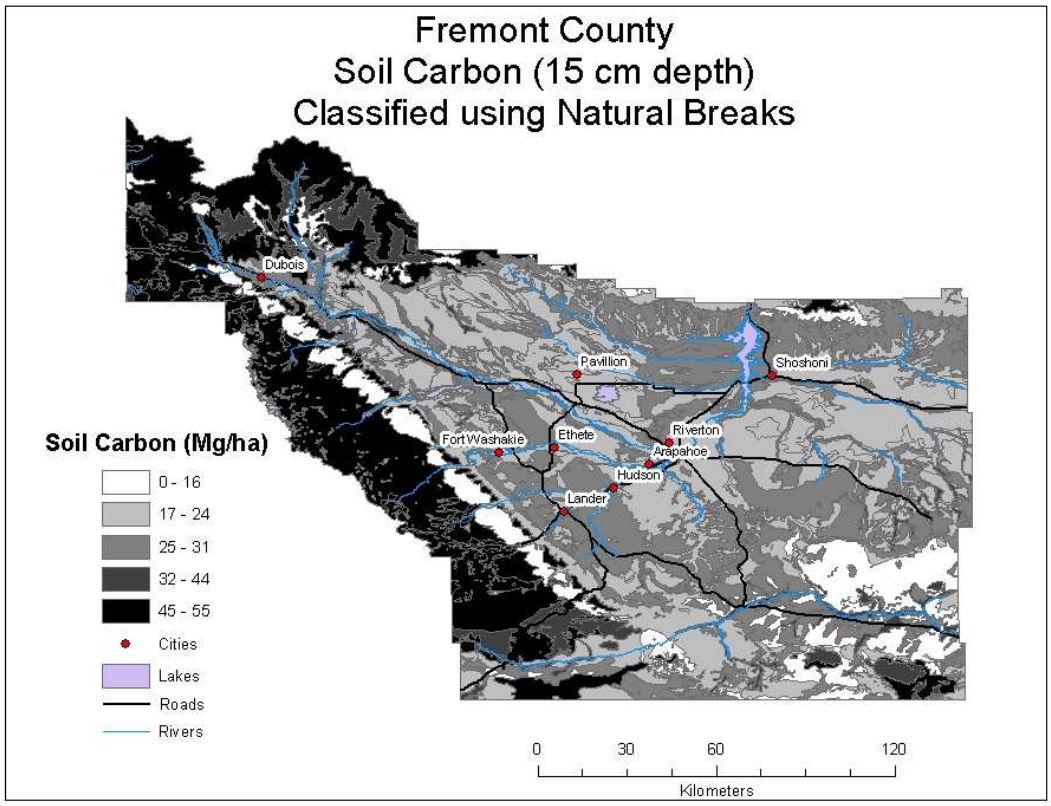

Converse County
Soil Carbon (1 M depth)
Classified using Natural Breaks
N
Soil Carbon (Mg/ha)
48 - 56
57 - 69
70 - 82
83 - 88
89 - 114
Cities
Lakes
Roads
Rivers
Rolling Hills
Glenrock
Douglas
Lost Springs
0
25
50
100
Kilometers

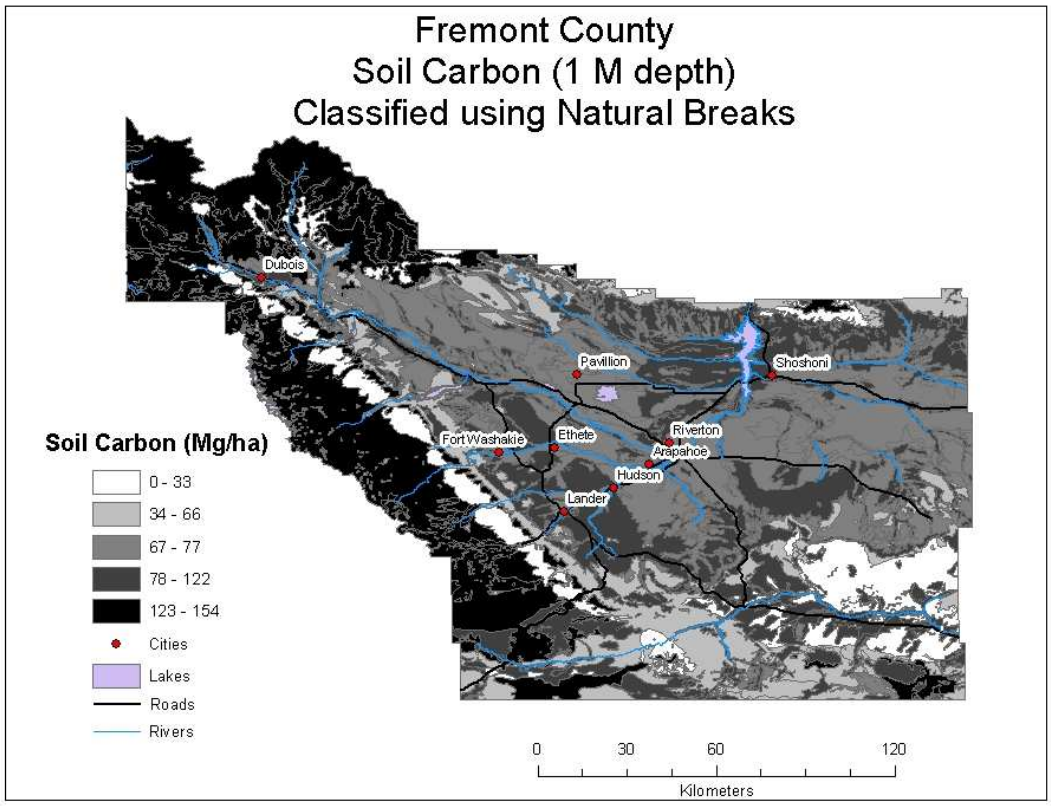
Crook County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



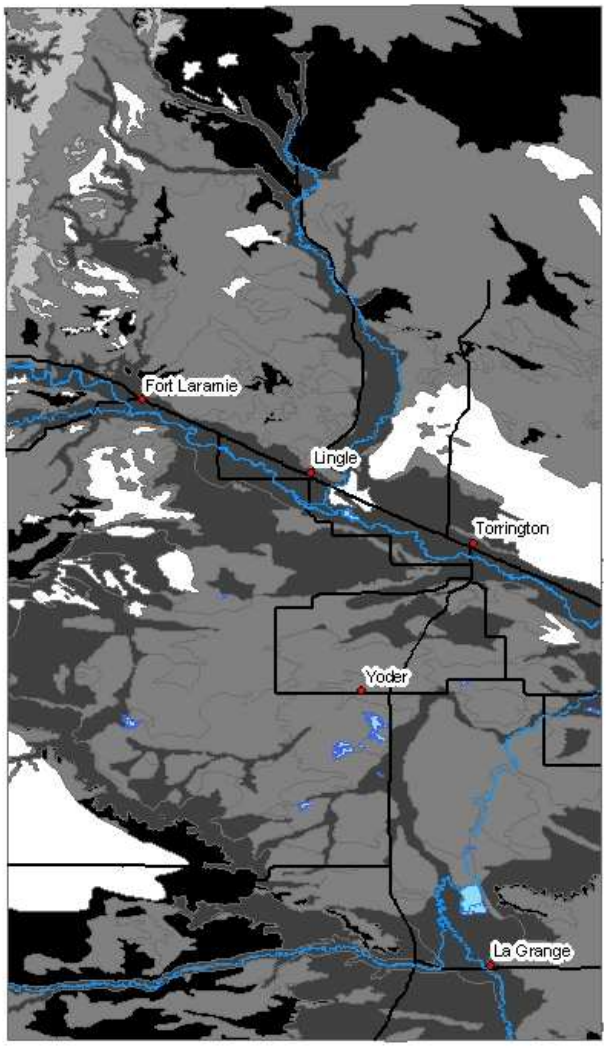
Crook County
Soil Carbon (1 M depth)
Classified using Natural Breaks




Fremont County
Soil Carbon (15 cm depth)
Classified using Natural Breaks
Dubois
Pavillion
Shoshoni
Riverton
Arapahoe
Fort Washakie
Ethete
Hudson
Lander
Soil Carbon (Mg/ha)
0 - 16
17 - 24
25 - 31
32 - 44
45 - 55
Cities
Lakes
Roads
Rivers
0
30
60
120
Kilometers


Fremont County
Soil Carbon (1 M depth)
Classified using Natural Breaks
Dubois
Pavillion
Shoshoni
Riverton
Arapahoe
Ethete
Fort Washakie
Hudson
Lander
Soil Carbon (Mg/ha)
0 - 33
34 - 66
67 - 77
78 - 122
123 - 154
Cities
Lakes
Roads
Rivers
0
30
60
120
Kilometers

Goshen County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



N

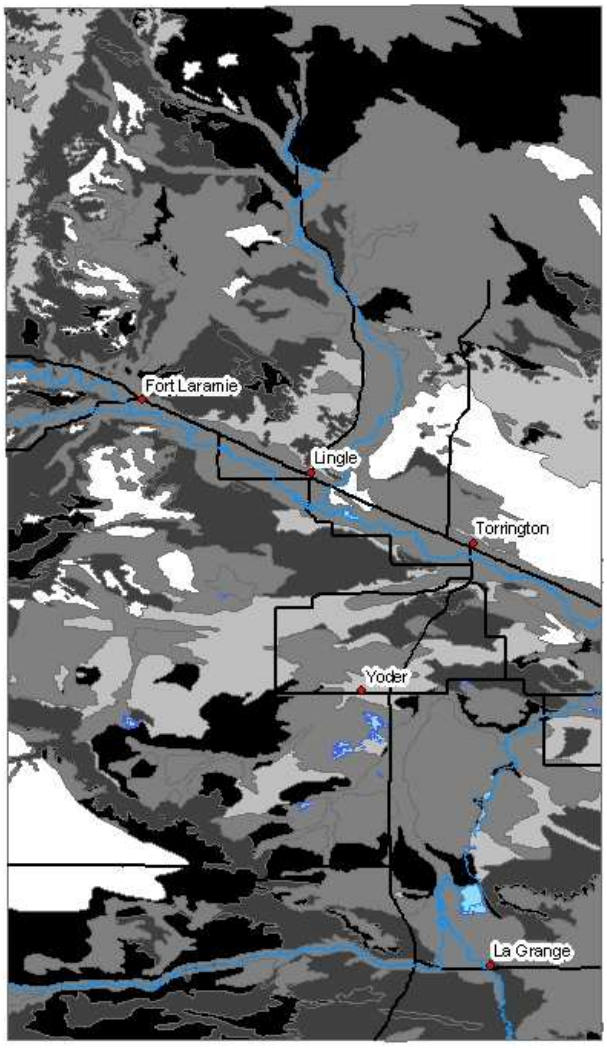
Soil Carbon (Mg/ha)

- 0
- 1 - 12
- 13 - 22
- 23 - 26
- 27 - 34
- Cities
- Lakes
- Roads
- Rivers

0 15 30 60

Kilometers

Goshen County
Soil Carbon (1 M depth)
Classified using Natural Breaks



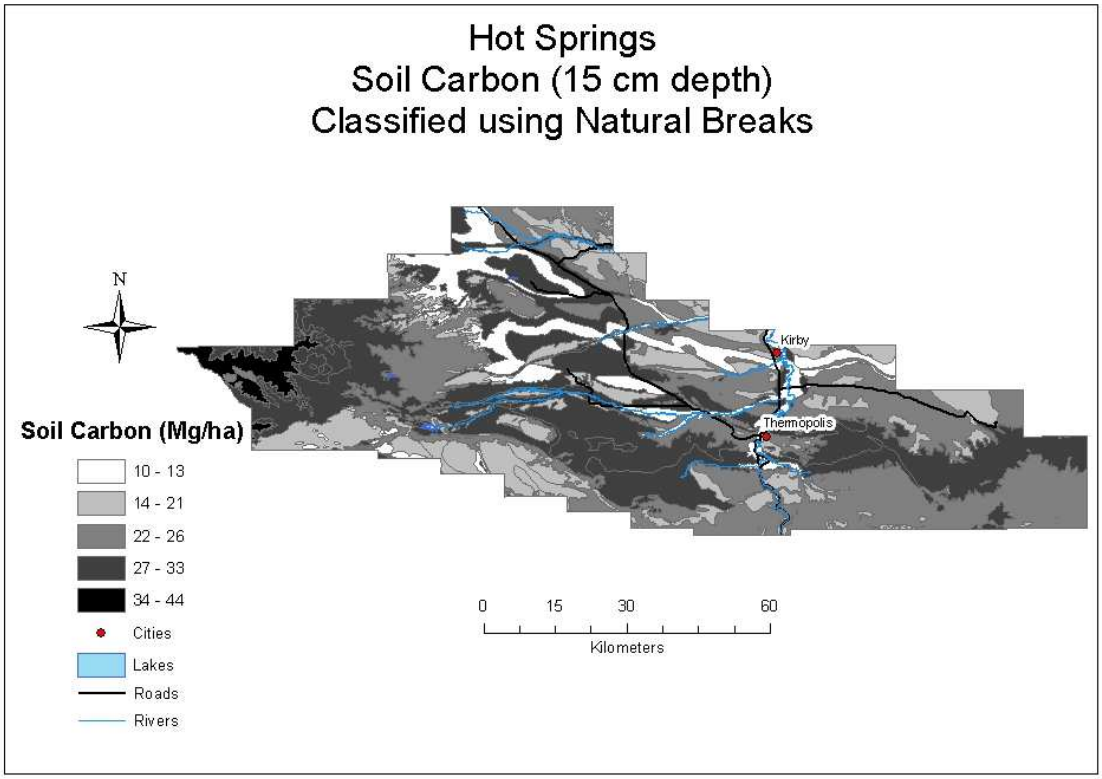
N

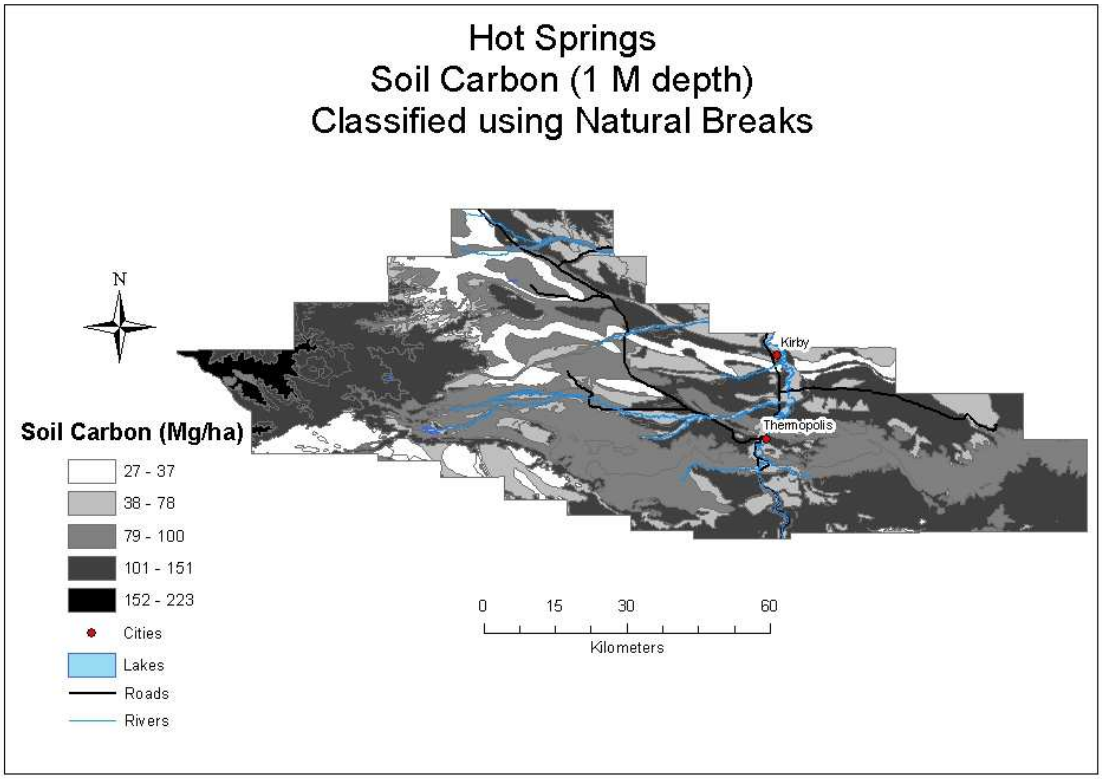
Soil Carbon (Mg/ha)

- 0
- 1 - 60
- 61 - 80
- 81 - 91
- 92 - 97
- Cities
- Lakes
- Roads
- Rivers

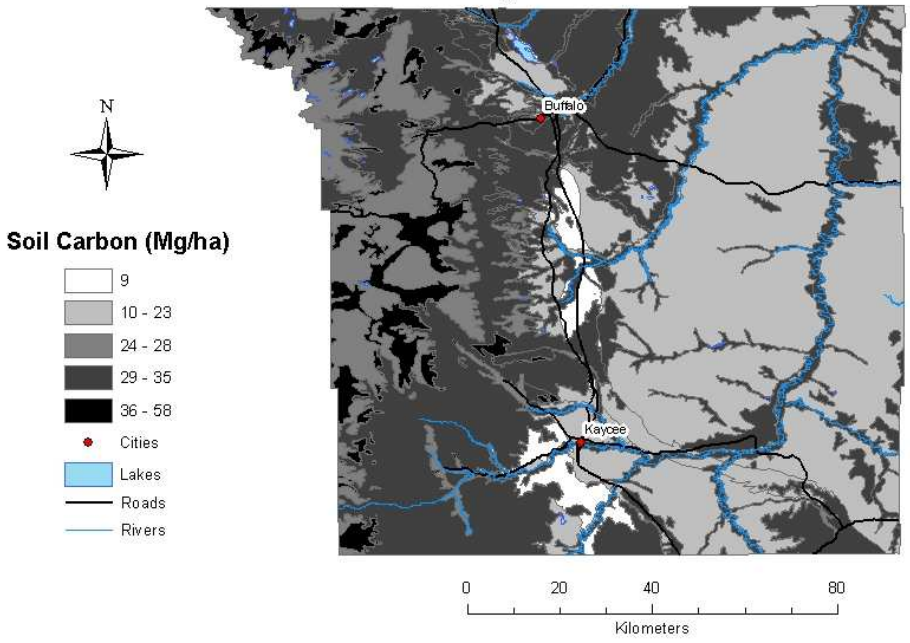
0 15 30 60

Kilometers

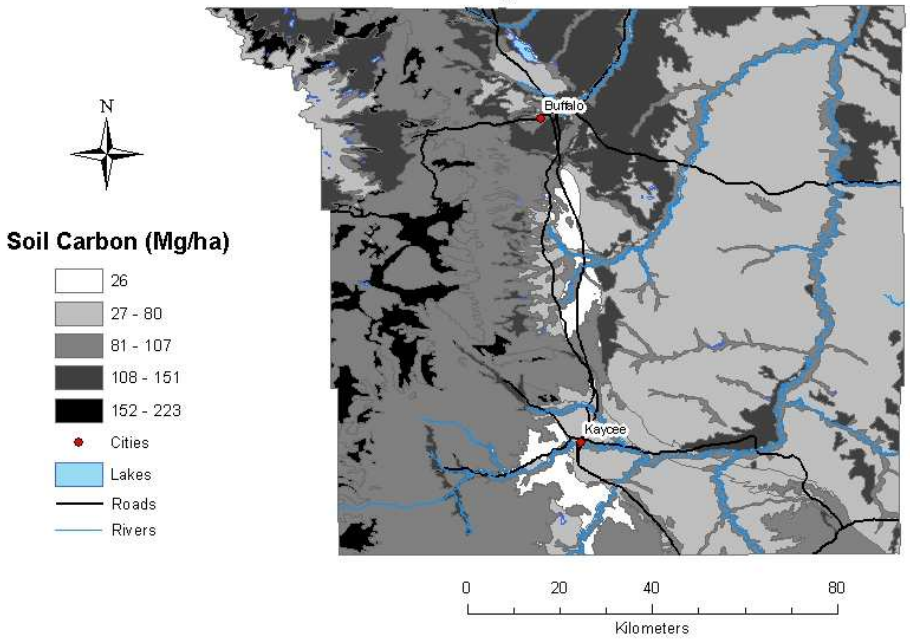

Hot Springs
Soil Carbon (15 cm depth)
Classified using Natural Breaks
N
Kirby
Thermopolis
Soil Carbon (Mg/ha)
10 - 13
14 - 21
22 - 26
27 - 33
34 - 44
Cities
Lakes
Roads
Rivers
0
15
30
60
Kilometers


Hot Springs
Soil Carbon (1 M depth)
Classified using Natural Breaks
N
Kirby
Thermopolis
Soil Carbon (Mg/ha)
27 - 37
38 - 78
79 - 100
101 - 151
152 - 223
Cities
Lakes
Roads
Rivers
0
15
30
60
Kilometers

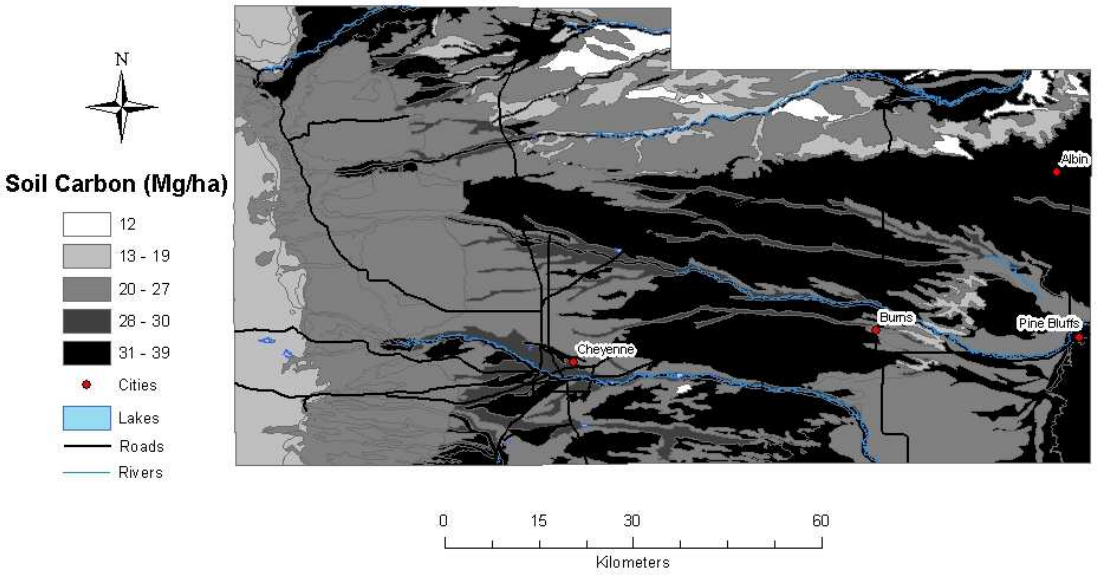
Johnson County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



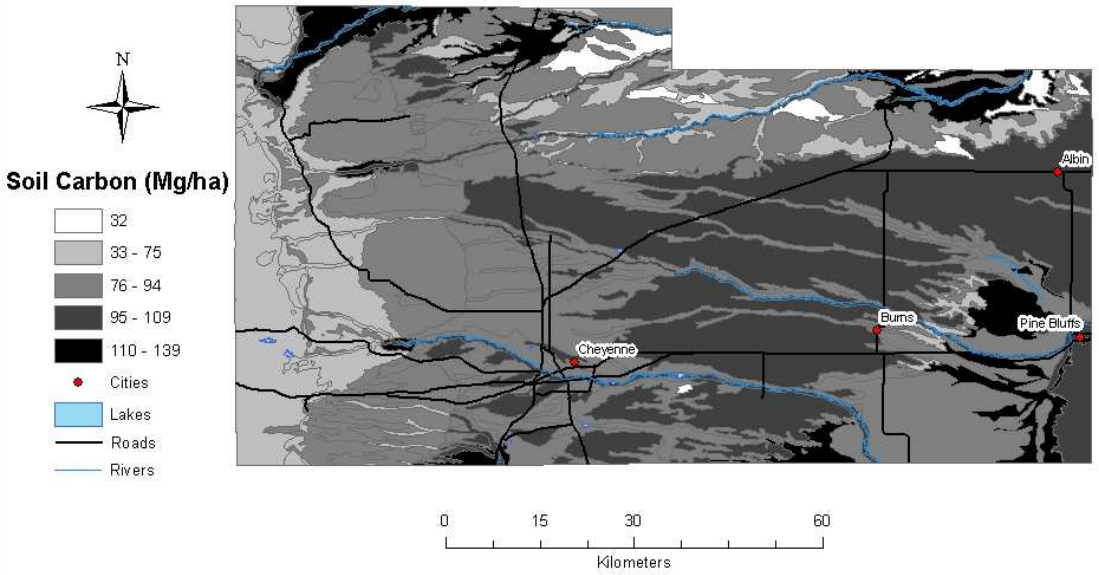
Johnson County
Soil Carbon (1 M depth)
Classified using Natural Breaks



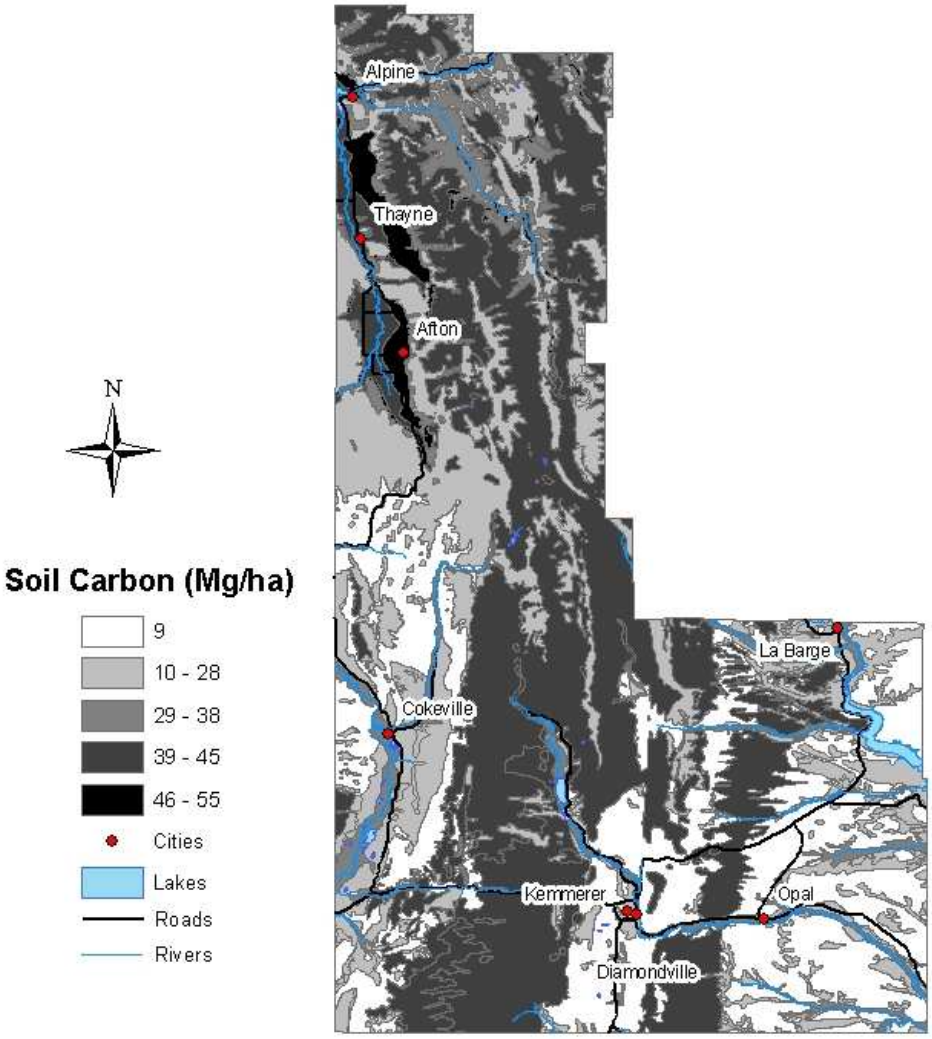
Laramie County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



Laramie County
Soil Carbon (1 M depth)
Classified using Natural Breaks



Lincoln County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



N

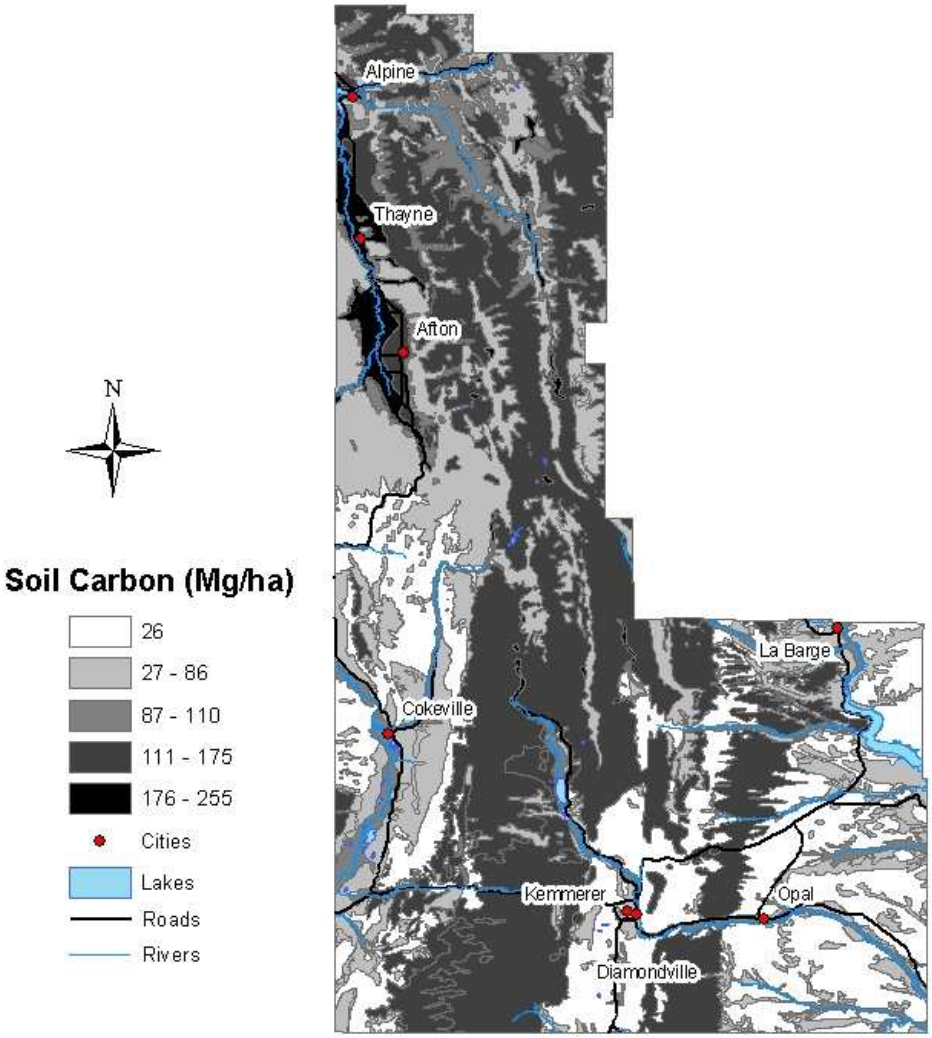
Soil Carbon (Mg/ha)

- 9
- 10 - 28
- 29 - 38
- 39 - 45
- 46 - 55
- Cities
- Lakes
- Roads
- Rivers

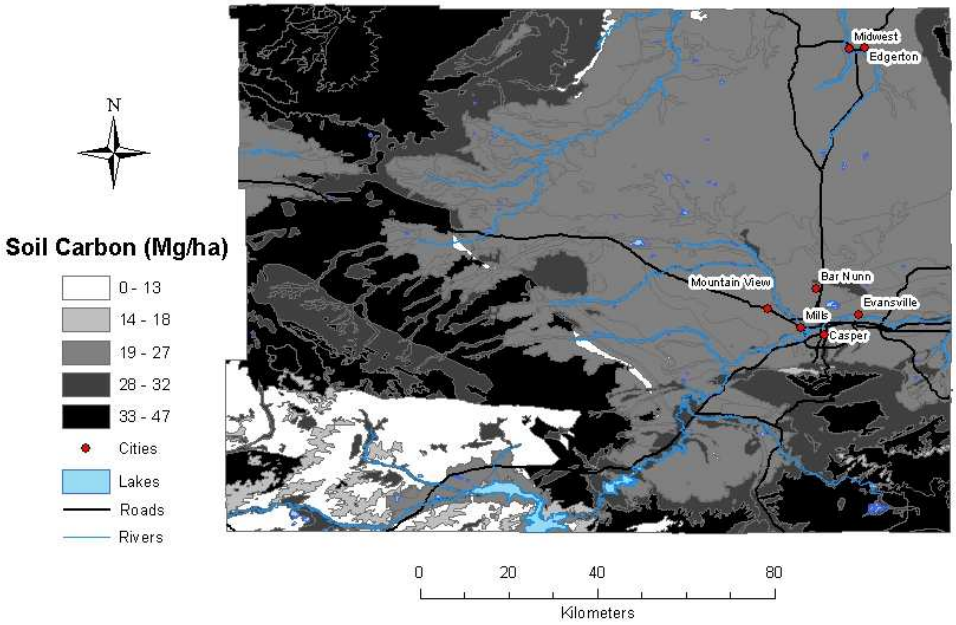
0 25 50 100

Kilometers

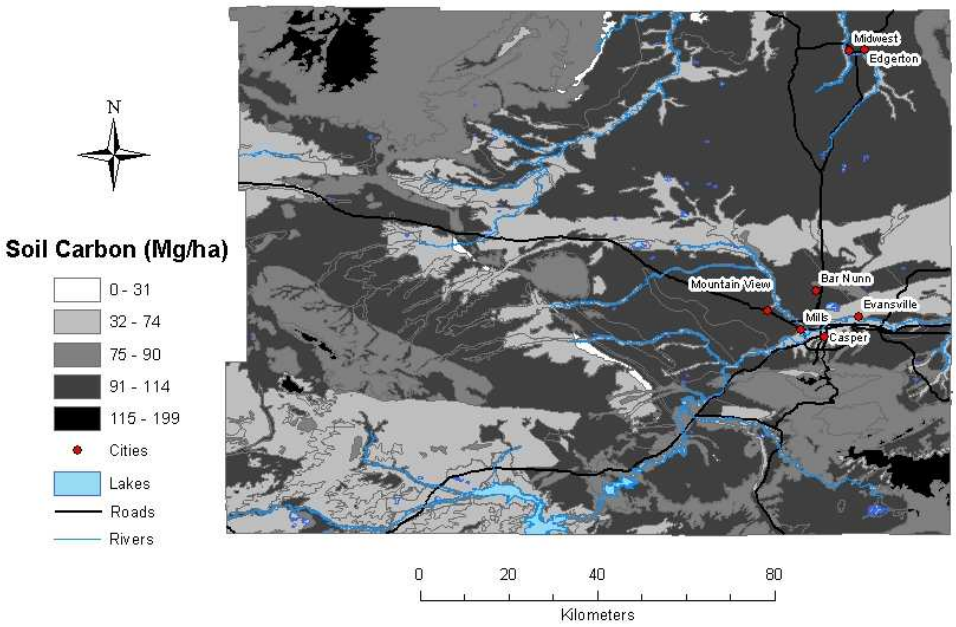
Lincoln County
Soil Carbon (1 M depth)
Classified using Natural Breaks



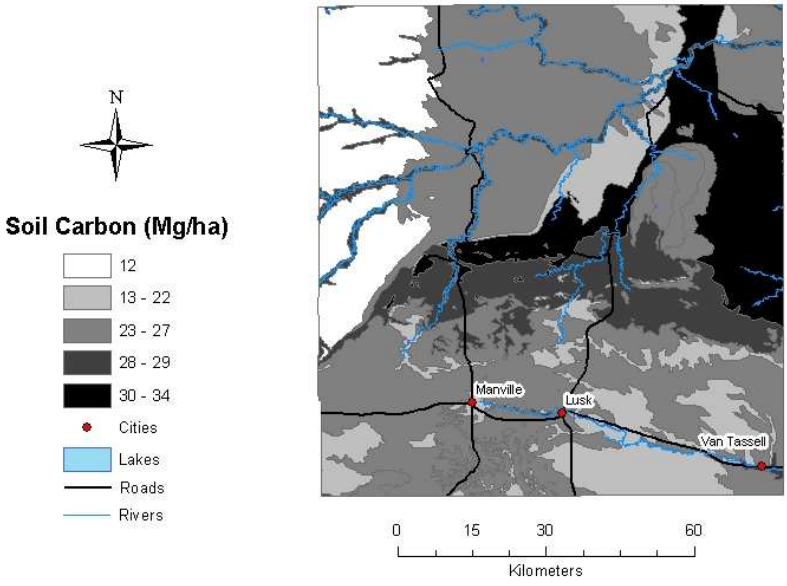
Natrona County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



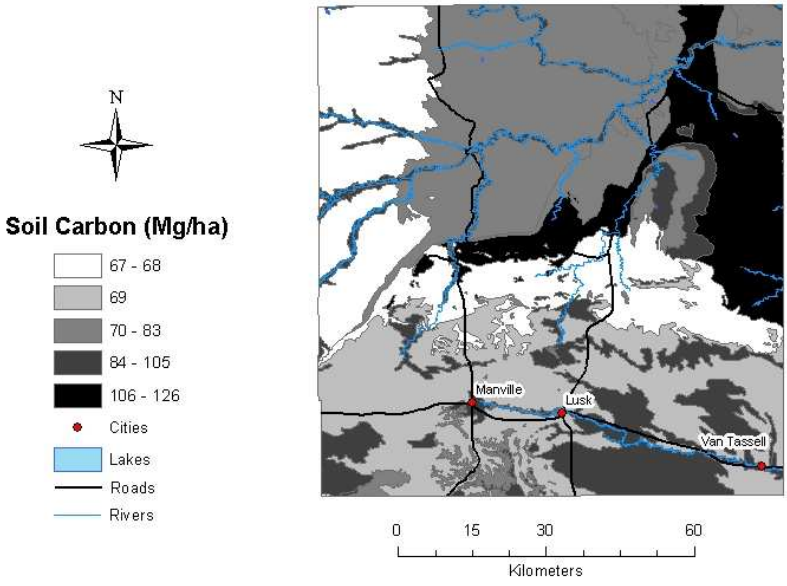
Natrona County
Soil Carbon (1 M depth)
Classified using Natural Breaks



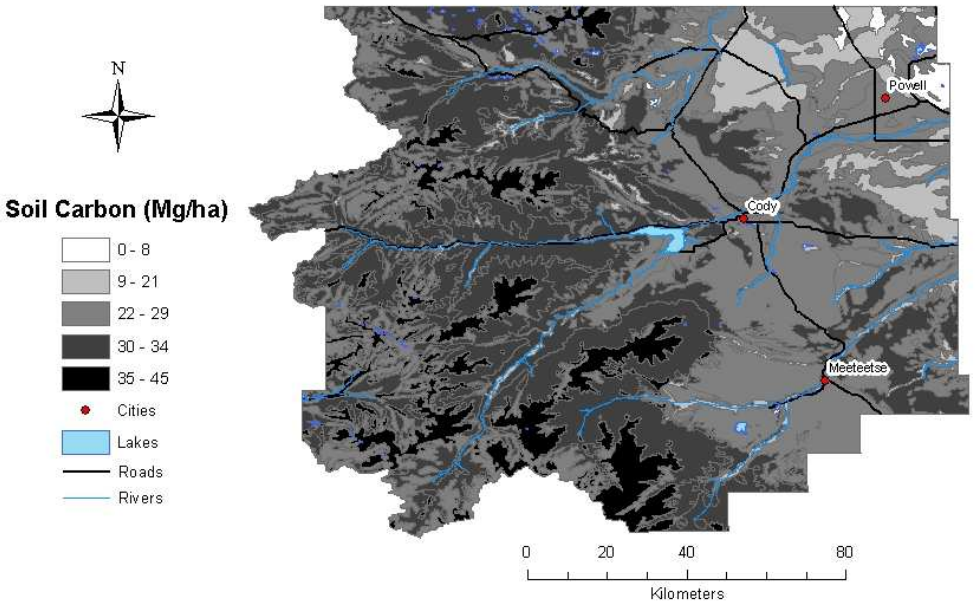
Niobrara County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



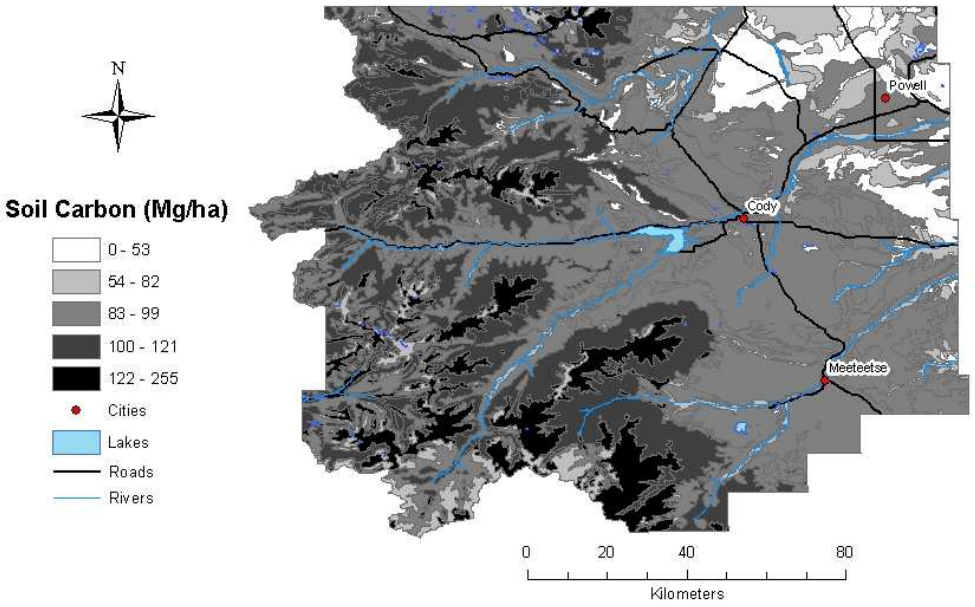
Niobrara County
Soil Carbon (1 M depth)
Classified using Natural Breaks



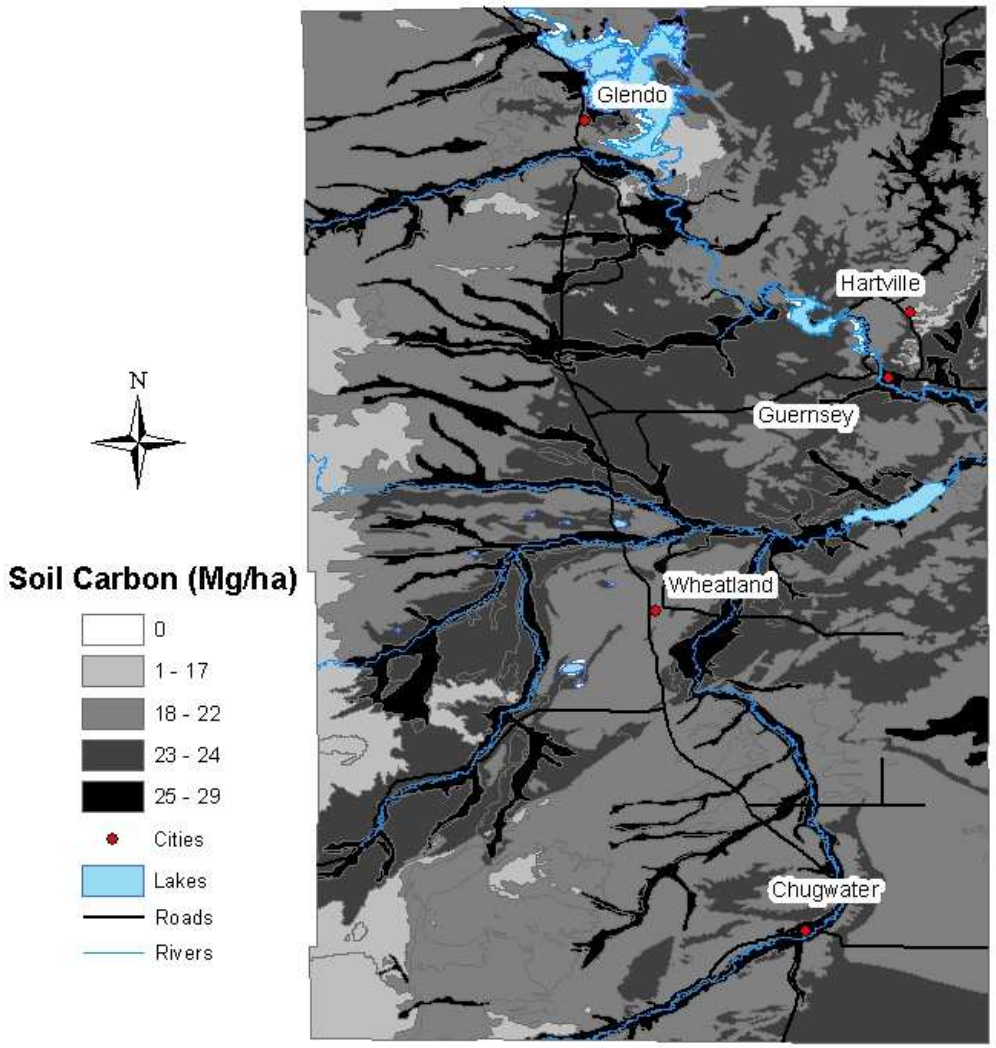
Park County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



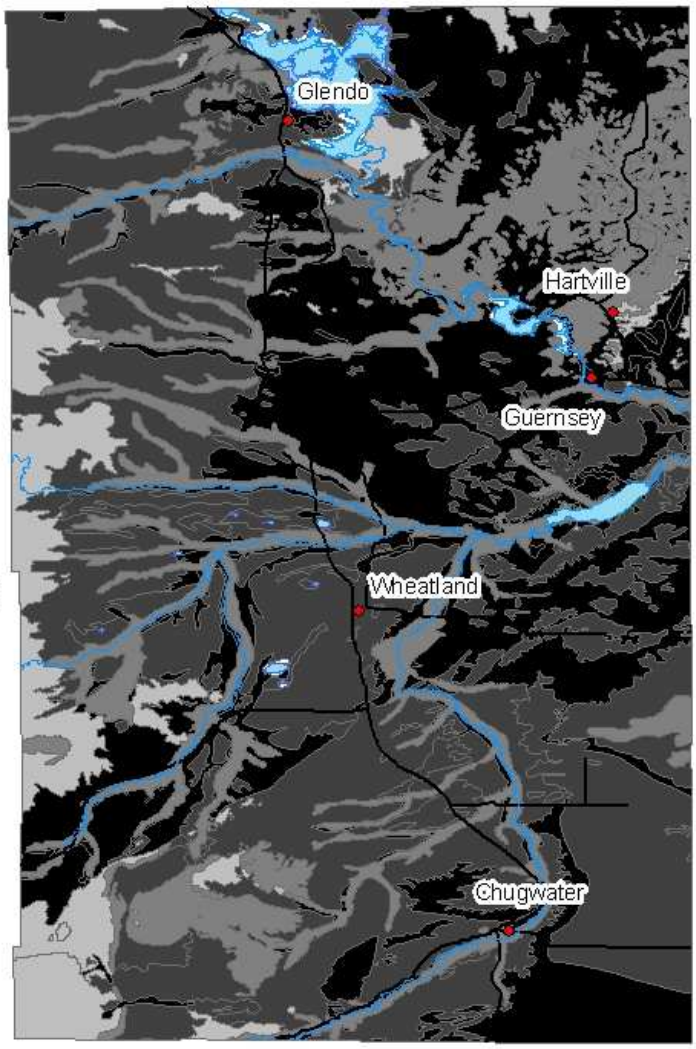
Park County
Soil Carbon (1 M depth)
Classified using Natural Breaks



Platte County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



Platte County
Soil Carbon (1 M depth)
Classified using Natural Breaks



N

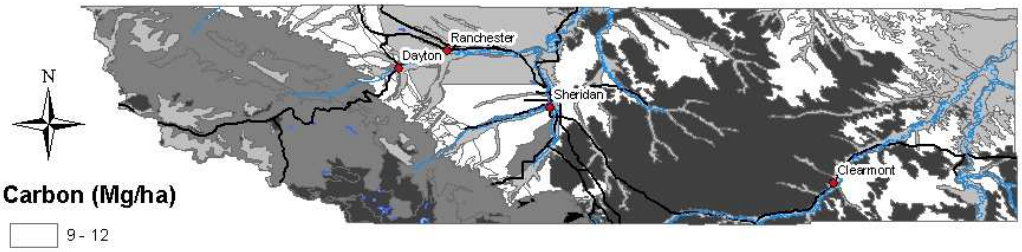
Soil Carbon (Mg/ha)

- 0
- 1 - 48
- 49 - 74
- 75 - 89
- 90 - 103
- Cities
- Lakes
- Roads
- Rivers

0 15 30 60

Kilometers

Sheridan County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



N

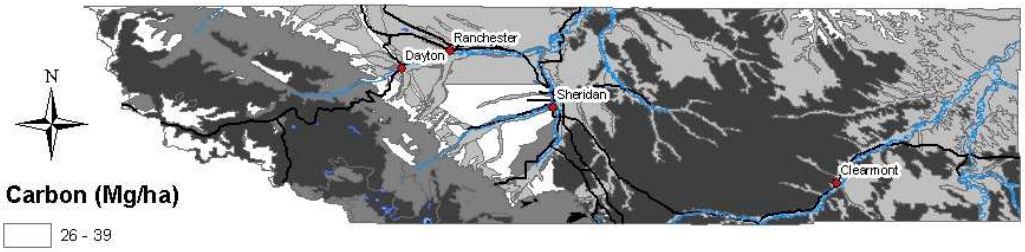
Soil Carbon (Mg/ha)

- 9 - 12
- 13 - 23
- 24 - 31
- 32 - 45
- 46 - 58
- Cities
- Lakes
- Roads
- Rivers

0 20 40 80

Kilometers

Sheridan County
Soil Carbon (1 M depth)
Classified using Natural Breaks



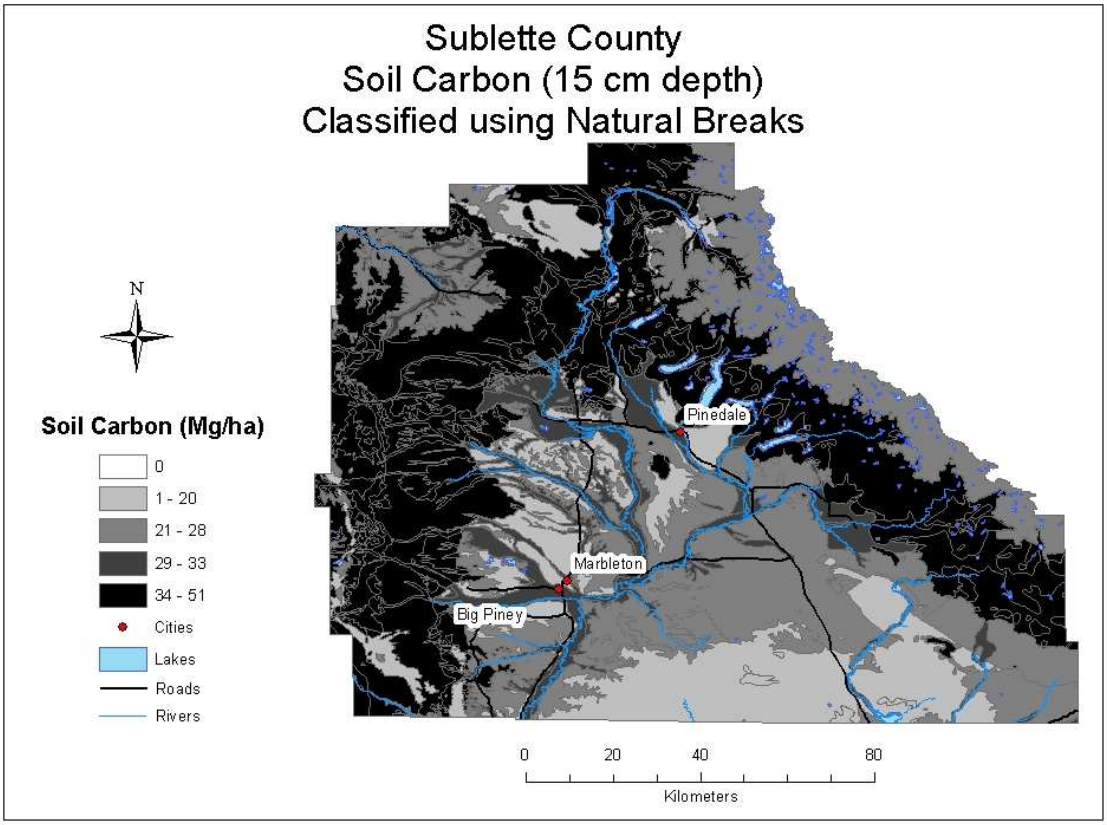
N

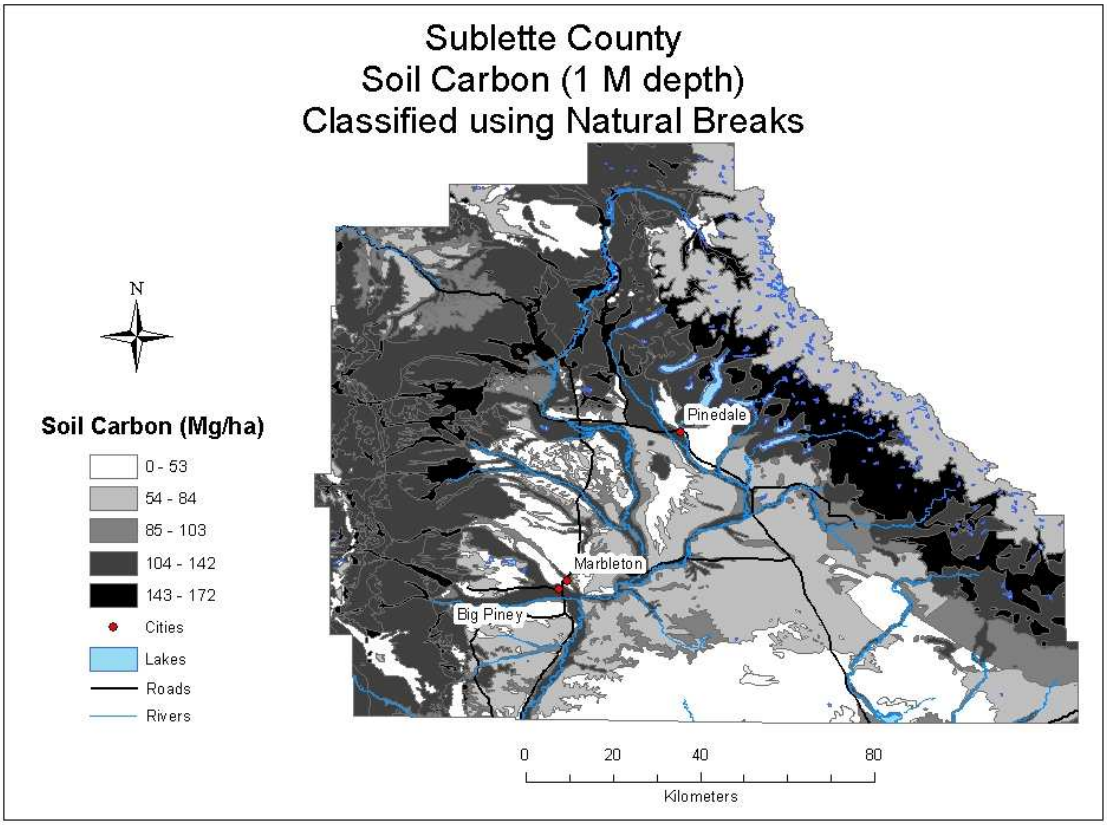
Soil Carbon (Mg/ha)

- 26 - 39
- 40 - 63
- 64 - 87
- 88 - 129
- 130 - 255
- Cities
- Lakes
- Roads
- Rivers

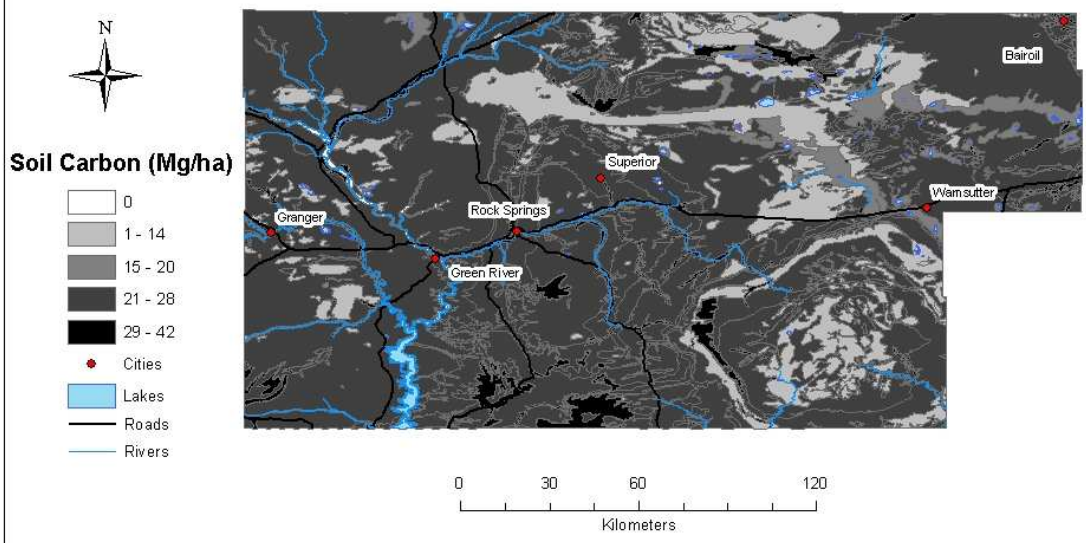
0 20 40 80

Kilometers

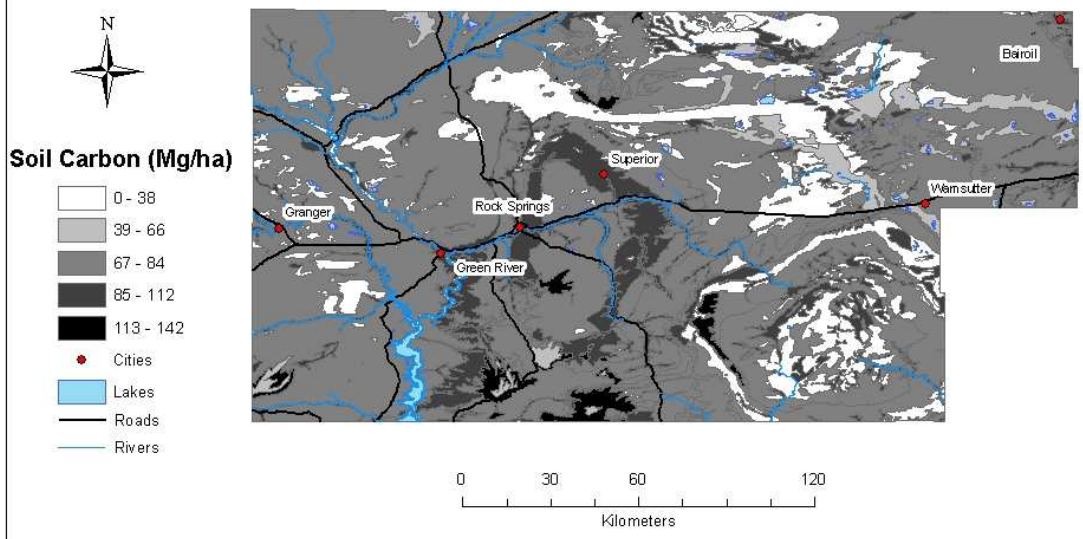

Sublette County
Soil Carbon (15 cm depth)
Classified using Natural Breaks
N
Soil Carbon (Mg/ha)
0
1 - 20
21 - 28
29 - 33
34 - 51
Cities
Lakes
Roads
Rivers
Pinedale
Marbleton
Big Piney
0
20
40
80
Kilometers


Sublette County
Soil Carbon (1 M depth)
Classified using Natural Breaks
N
Soil Carbon (Mg/ha)
0 - 53
54 - 84
85 - 103
104 - 142
143 - 172
Cities
Lakes
Roads
Rivers
Pinedale
Marbleton
Big Piney
0
20
40
80
Kilometers

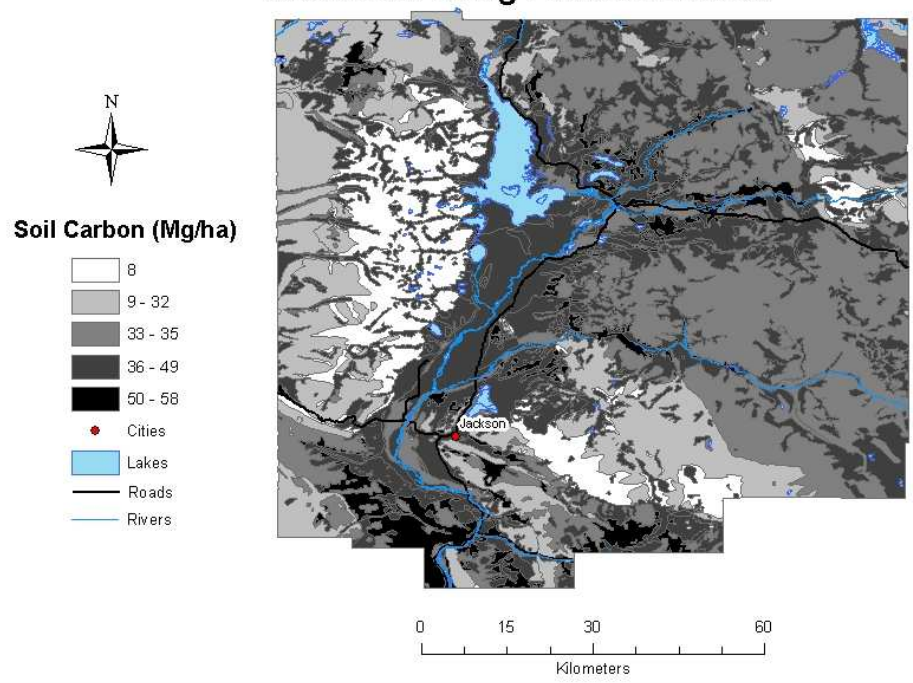
Sweetwater County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



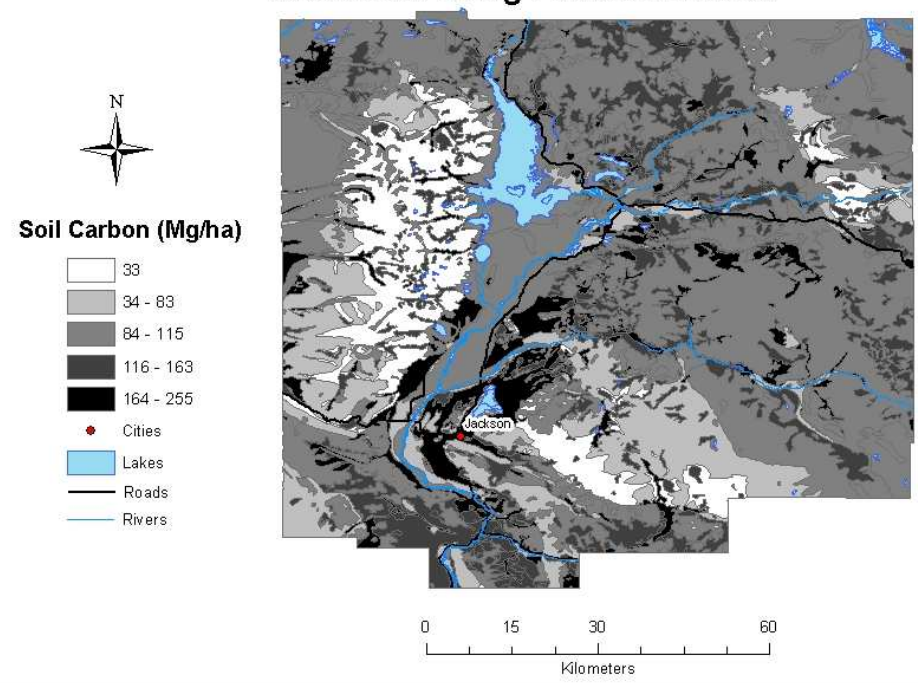
Sweetwater County
Soil Carbon (1 M depth)
Classified using Natural Breaks



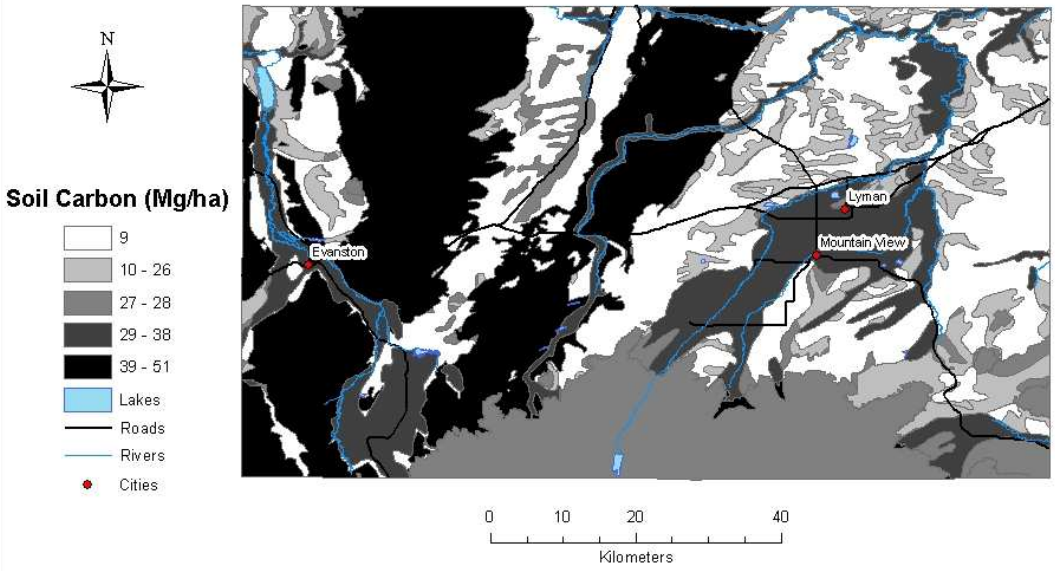
Teton County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



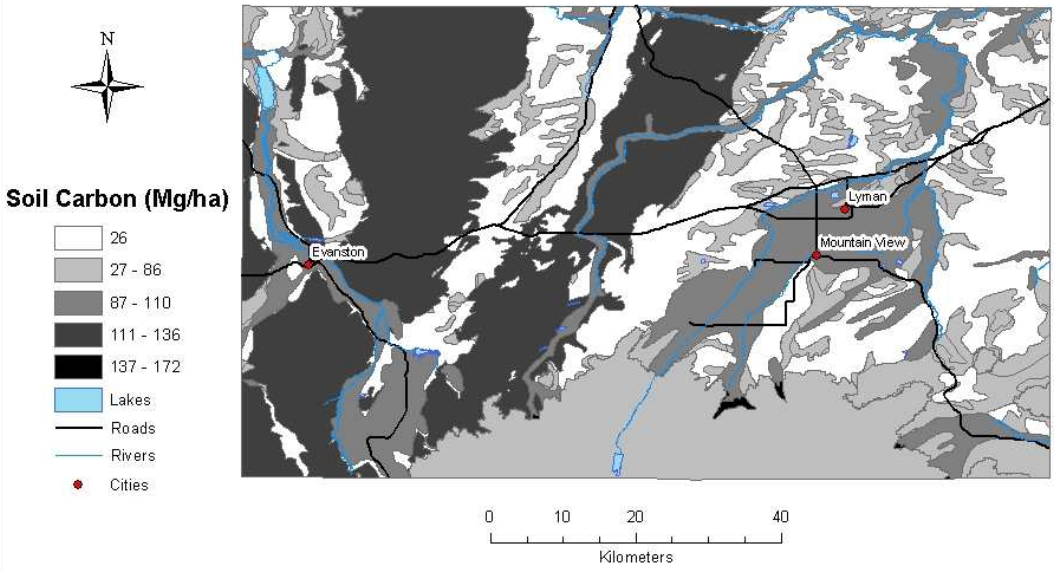
Teton County
Soil Carbon (1 M depth)
Classified using Natural Breaks



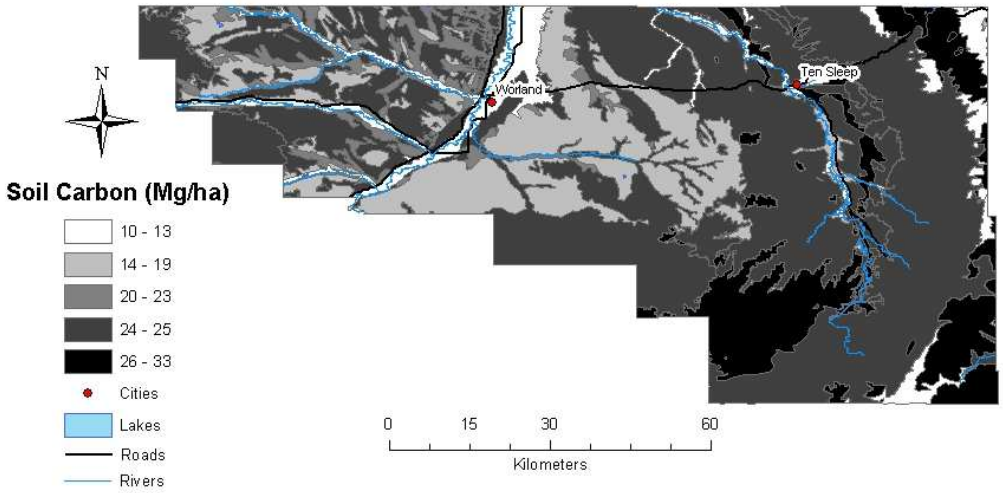
Uinta County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



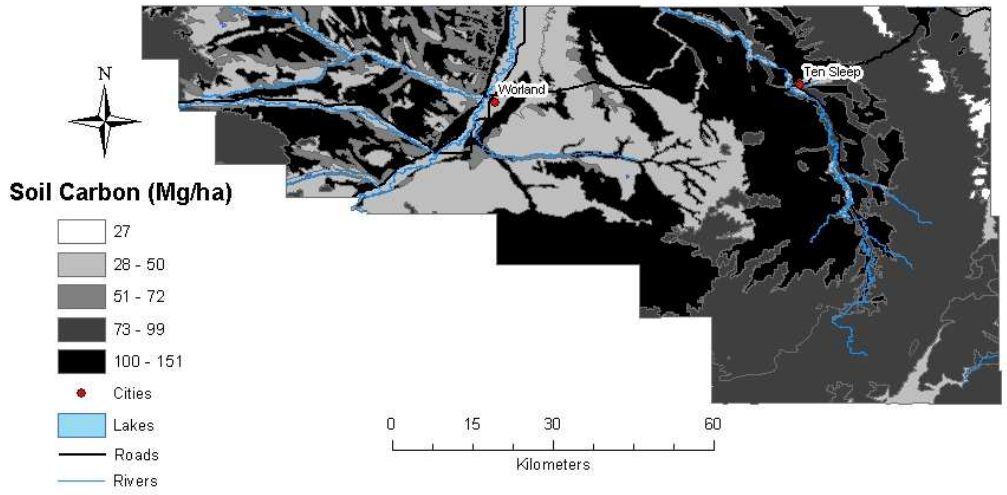
Uinta County
Soil Carbon (1 M depth)
Classified using Natural Breaks



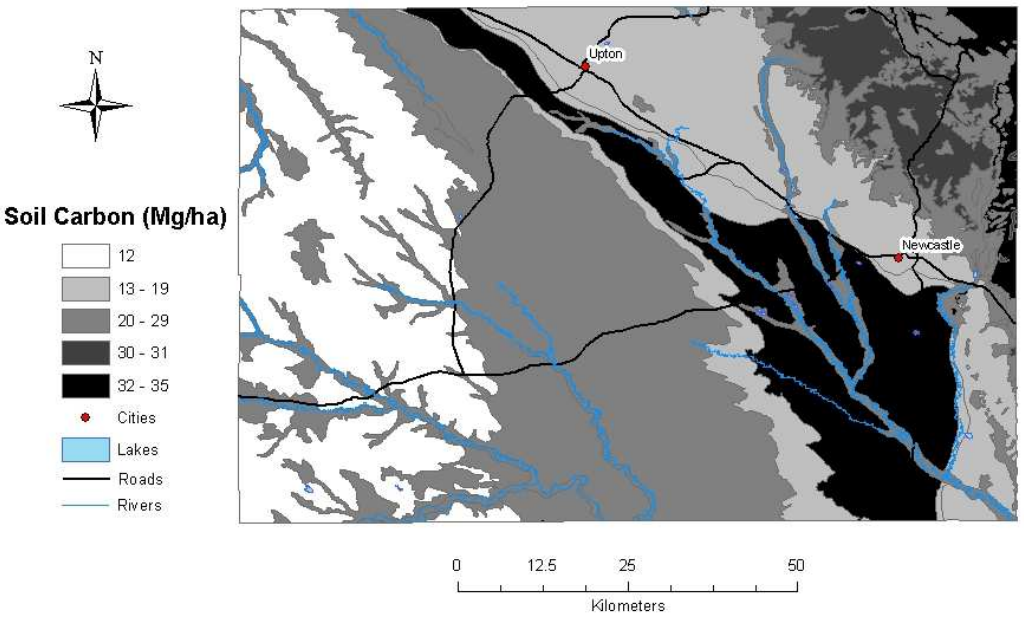
Washakie County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



Washakie County
Soil Carbon (1 M depth)
Classified using Natural Breaks



Weston County
Soil Carbon (15 cm depth)
Classified using Natural Breaks



Weston County
Soil Carbon (1 M depth)
Classified using Natural Breaks